THE AMERICAN ENCYCLOPEDIA AND DICTIONARY OF OPHTHALMOLOGY

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ASSISTED BY A LARGE STAFF OF COLLABORATORS

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Ophthalmology, Legal relations of. See **Legal relations of ophthalmology.**

Ophthalmology, Literature of. The history of ophthalmology is built up from its literature. It is impossible to dissociate them. Therefore, much about the literature will be found in the section on **Ophthalmology, History of.** In the accounts of special conditions or operations the more important parts of their literature are usually referred to, and should be sought under the headings of those special topics. In this section will be discussed the development of ophthalmic literature throughout the world, its forms, present status, classification, collections, and suggestions with regard to its use.

The literature of ophthalmology begins with the beginnings of literature, but implies a long precedent period of development for ophthalmic science and art, the accumulation of much knowledge, the formulation of many procedures, the firm establishment of customs. This is seen in the perpetuation of standard prescriptions of Egyptian oculists in the papyri, or in the regulations fixing fees for certain operations, and penalties for their failure, in the code of Hammurabi. At first ophthalmic literature consisted only of short passages contained in more general treatises, as in the instances above mentioned; although for the papyrus of Ebers a specialist in ophthalmology was secured to write this particular portion. Later whole literary works were devoted to the eye and its diseases; and still later minute subdivision of the general topic became the subjects of particular works and monographs.

In the beginning a book or monograph came into existence on the initiative of a particular author, and was circulated and preserved by making copies of it by hand, often with additions or omissions, intentional or inadvertent, made by the copyist. In the ancient literature many that purport to be original works are but copies or variants of books written before. To a large extent this is true of the current literature of today, that which is wholly original constituting but a small proportion of the new literature; and only a small part of that has much permanent interest or value. In regard to ophthalmology, as in regard to other topics, the works of Hippocrates became the foundation for the works of Galen; and the latter the basis for most of the writing done well into the middle ages. The literature of Greece reflected that of Egypt, and modern ophthalmic literature builds on all that has gone before.

The older works were preserved and circulated wholly in manuscript. Only with the formal publication of books by printing does it become possible to fix the exact form and content of an author's

work. The first book on the eye printed from type was that of Benevenutus Grassi (as his name appears in the book, or Grapheus, as more commonly rendered). It is entitled "*De Oculis eorumque Aegritudinibus et Curis,*" and was published in Ferrara in 1474, only a few years after printing became known outside of Mainz and two years before it was introduced into England. It is printed in Latin in seventy small pages, without page headings, the topic headings being in the same type as the text. Numerous manuscripts of this book exist which vary from one another. Most are in Latin, but others are in Provençal, old French and old English, while one purports to be translated from Hebrew although no Hebrew text has been found. This writer is spoken of as Benevenuto, of Jerusalem and also as of Salerno. He probably lived and wrote before the year 1300. Other editions of his book were printed in 1497, 1500 and 1549 in Venice. A copy of this book is in the Library of the College of Physicians of Philadelphia.

With the advent of printing, books rapidly developed their present general characteristics. There was the title page, giving name, titles and achievements of the author, and the inscription to some famous man, often a duke, sometimes a king. The division into chapters similar to the practice today, the use of the chapter and page headings; an elaborate table of contents was soon introduced, and later the alphabetical index; still sometimes omitted to the grief of the reader.

The books first published were generally based on the manuscript literature of the past; but often did not purport to come from such sources. Only later were accurate reproductions of the older authorities made. Only in the last generation Hirschberg has worked out the manuscripts of the Arabs (700-1400); Berger has given us the book of Pietrus Hispanus (1248). Pansier has rendered accessible the ophthalmology of the early middle ages, and Ebers has deciphered the Egyptian papyrus of 1550 B. C., that now is known by his name. It is probable that in the literature of China much yet remains unnoticed that will be of interest to the ophthalmologist. When it became possible for an author to spread abroad a hundred copies of his book, men ceased to be satisfied with merely copying and emendating the works of Galen, or other traditional authorities.

But it took a century to get started in the writing of really original works. Roger Bacon living from 1214 to 1294 had left in manuscript important contributions to our knowledge of refraction. His works began to be published in 1485 and appeared from time to time for 130 years. Hieronymi Mercurialis (1530-1606) published in 1591

a Latin duodecimo of 192 pages upon affections of the eye and ear. There were eleven chapters, 137 pages, devoted to the eye; and in addition to the index of headings (table of contents) there is an alphabetical index covering the whole book, justifying the claim of the title page "Cum Indicie Copiosiss." Of Gaulther Hermann Ryff, a compiler who published a quarto at Würzburg in 1548, Beer says that the bad moral character ascribed to him by all men makes his work useless.

Johan Kepler (1571-1630) published his first account of the structure of the eye in 1604, and his important work on dioptrics in 1610. Of the work of Georg Bartisch sufficient mention is made in his biography, Vol. II, p. 888, of this *Encyclopedia.* Jacques Guillemeau (1560-1613) published in 1605, a book in which he discussed 113 diseases of the eye.

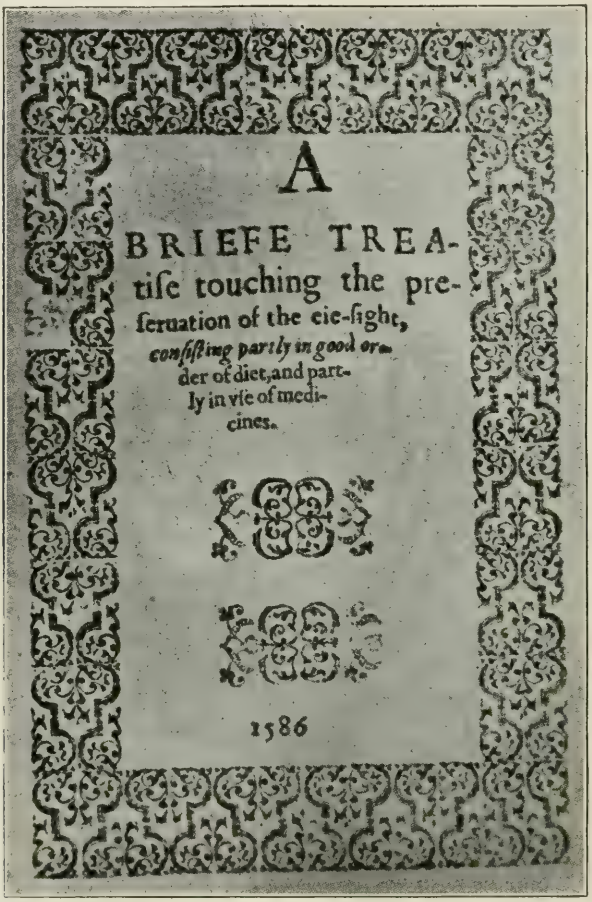
Richard Banister translated this into English, and published it in 1622, the first *systematic treatise* on diseases of the eye in English. Specimens of the verses with which he adorned it are quoted in his biography. See Vol. II, p. 879, of this *Encyclopedia.*

The first work printed in the English language on the medical and hygienic treatment of eye diseases was by Walter Bailey (Bayley, Baley or Baily). See Vol. II, p. 864, of this *Encyclopedia.* This little volume ran through three editions, the first dated 1586. It appeared without the writer's name on the title page, which is here reproduced from a copy in the library of Dr. Lewis Taylor of Wilkes-Barre, Pa., to whom the Editor is indebted for the illustration. The only other copy known to exist in America is in the library of the Surgeon General of the U. S. Army. It consists largely of directions for the use of eyebright (see **Euphrasia**, p. 4551, Vol. VI, of this *Encyclopedia*) and contains also much shrewd and interesting advice regarding the dietetic and local treatment of certain eye symptoms.

With the beginning of the 18th century, which Hirschberg calls the rebirth of ophthalmology, appear books dealing with only a part of the subject, or with a single topic. Michael Brisseau, in 1706 and 1707, published his writings on cataract and glaucoma. Pointing out that cataract is the opaque lens, Hieronymus Fabricius (1537-1619) corrected the error of previous authorities, those who followed Galen and located the lens farther back. Brisseau's work raised a discussion that was soon joined by Maître Jan (France 1650-1725), John Thomas Woolhouse (England 1650-1730), William Cheselden (England 1685-1752), and many others. In 1748 began to appear the writings of Jacques Daviel on the extraction of cataract.

From this time the number of monographs has enormously in-

creased. Each new discovery or departure from earlier methods of practice has given rise to its own special literature, often of vast proportions. Some of these subdivisions of the literature of ophthalmology receive special notice below, although most of them are to be traced under the subjects to which they refer. In this century the



Facsimile of the Title Page, Walter Bailey's Work on the Medical Treatment of Eye Diseases, the First Book of the Kind Published in the English Language.

general treatises increased in number. Among the most important are those of Antoine Maître-Jan, 1707; Jacob Hovius, 1716; Charles de Saint Yves, 1722; Hermann Boerhaave, whose work *de Morbis Oculorum*, seems to have been published in 1750 after his death; William Porterfield, 1759; Jean Janin, 1767, and J. J. Plenk, 1778.

George Joseph Beer wrote a *Repertorium* purporting to notice all the works on ophthalmology that had appeared up to 1797. It was published in Vienna in 1799. It is divided into three volumes aggregating 524 pages. Each volume is furnished with a Latin and a German title page. The book is written in German. The first part gives elementary works, systems and compendiums. The second part includes the external diseases, lids, lachrymal apparatus, nasal sinuses, and conjunctiva and cornea. The third part includes writings on the internal and general diseases of the eye. In one century the literature of ophthalmology had become highly specialized.

In the 19th century the volume of this literature increased enormously. According to Pansier, there were 130 complete treatises produced as follows: In Germany and Austria, 45; England and America, 38; France and Belgium, 31; Italy, 5; Spain and Holland, each 3, and Russia, 2. Of the number of books on special subjects, monographs and journal articles no reliable estimate has been formed.

The literature of particular subjects has been developed from time to time in this way. The Ebers papyrus dealt with remedies only, generally with prescriptions that seem to us to reflect chiefly ignorance and superstition. It mentions an operation for removal of the lashes, and gives no description of symptoms. The code of Hammurabi dealt with legal requirements, fees and penalties. The writings of the Greeks and Arabs garnered many clinical facts, and may be regarded as the beginning of a clinical literature. But it was fettered by ignorance of anatomy and as to the normal function of the various structures within and around the eyeball.

The correction of Galen's mistaken idea about the position of the lens has been referred to. In 1660 Nicolas Steno, or Stensen, had described the lachrymal apparatus. H. Meibomius in 1670 described the glands since known by his name. Johannes Gottfried Zinn in 1755 published *Oculi Humani*, his classical treatise on the anatomy of the eye, and in 1791 to 1796 Samuel Thomas Soemmering published his anatomical work. Each contribution to the exact knowledge of anatomy implied an advance in the knowledge of physiology.

Following these advances there began a series of books, monographs and short papers on cataract, constituting its special literature, which continues to appear without diminution, as generation after generation studies the causation and undertakes the cure of the condition. Early in the 18th century Anel published his monograph on lachrymal fistula, and the literature of lachrymal disease was begun. With the better understanding of cataract, clearer ideas developed with

regard to glaucoma, and the literature dealing with glaucoma began to accumulate.

But the greatest development of a new literature followed the invention of the ophthalmoscope. In 1851 Helmholtz published his modest description of it; and immediately numerous workers began to apply it and record new facts brought to their notice by it. Mention of these began to appear in all parts of the literature of ophthalmology, and larger works, like the ophthalmoscopic atlases, came into being to record a whole new department of pathology. This literature created by the ophthalmoscope consists of: First, papers on the optical and mechanical construction of the instrument; descriptions of the enormous number of modifications that have been proposed. Second, accounts of the methods of using the instrument which have been combined with the first, as in Helmholtz' original account, or the brochure of Anagnostakis (1854), or which are developed in manuals for the use of students or chapters in systematic works. Third, the pathology of the interior of the eye, or of intraocular structures sharing in general diseases.

The literature of ophthalmoscopy has steadily expanded; that of cataract quickly developed to a considerable volume, and has sustained a fairly steady increase and claim to general attention ever since. With other subjects the interest and output of literature has been variable. When Dieffenbach (Berlin, 1839) announced he had put into practice Stromeyer's suggestion of tenotomy for the cure of squint, a literature regarding the subject sprang up immediately. In Paris, Guerin promptly claimed priority, and in the United States books were quickly published by John H. Dix, of Boston, 1841; A. C. Post, New York, 1841; James Bolton, Richmond, Va., 1842; and Frank H. Hamilton, Buffalo, 1845, dealing with squint and the new method for its treatment. Other monographs and journal articles regarding the subject emanated from every important city of the world. Then the interest died down, to be revived fifteen years later by the works of von Graefe, Critchett, and others. Again the subject became one of minor importance until the writings of Stevens on heterophoria turned renewed attention to the disorders of ocular movements.

In a similar way the glaucoma literature became suddenly important when v. Graefe published the cure of it by iridectomy. Then it fell off, although a number of careful workers continued to study the problems of glaucoma and report their conclusions. The new literature was scanty until new operations were proposed for the relief of glaucoma, and the tonometer of Schiötz of general clinical

use was invented; since which time the glaucoma literature has rapidly increased.

The special department of the literature of ophthalmology which deals with physiologic optics has had a rather peculiar history. Although the properties of lenses were probably known to the ancients, and spectacles may have been used in China previous to their use in Europe in the 14th century, and something was known of optics among the Arabians, this special branch of knowledge may be said to have begun with the philosopher Roger Bacon (1214-1294). During the middle ages, when all learning remained in the monastery, there was some association of optics with medicine, but in the main they developed apart. Johannes Kepler (1571-1630), the great worker in theoretic optics; Scheiner (1595-1650), Descartes (1596-1650), Mariotte (1620-1684), Hooke (1635-1703) and Sir Isaac Newton (1642-1727) were all philosophers. Thomas Young was educated and practised as a physician; but his important observations on physiological optics were published in the *Philosophical Transactions of the Royal Society*. See **Eyeglasses and spectacles, History of.**

William Porterfield (Edinburgh) in his *Treatise on the Eye*, which deals systematically with ocular anatomy and physiology, devoted 283 pages to what might now be classed as physiological optics, then largely speculative. But it was not until Donders' book on the "*Accommodation and Refraction of the Eye*" (1864) set forth the enormous clinical importance of states of refraction that the literature of this branch of knowledge became thoroughly incorporated with that of ophthalmology. The union has been extremely fruitful in practical benefits, and this branch of ophthalmic literature has expanded rapidly.

Less striking instances of the same sort of expansion of the literature of ophthalmology have been seen recently when Marcus Gunn, in 1892, called attention to the ophthalmoscopic signs of high blood-pressure and arterio-sclerosis, and when E. von Hippel, in 1904, reported his results from the treatment of the ocular lesions of tuberculosis with tuberculin. Streams of general medical literature were thus mingled with that of ophthalmology, and new branches of the latter developed.

The forms taken by the literature of ophthalmology are nearly those of literature in general. Underlying all literature is the belief that the ideas it perpetuates are worthy of preservation, or dissemination. For early literature preservation was the more important. The libraries of baked clay tablets in Babylonia seemed admirably adapted to make a permanent record. But the carefully prepared papyrus of Egypt was also fairly permanent, and possessed other extremely

valuable characteristics. A very large number of ideas could thus be preserved in a small space, and the record was readily portable. Other methods of preserving a record, as seals, medals, coins, or sculpture, were resorted to relatively less. Paper, developed from the papyrus, and similar materials were used more and more; so that such records constitute practically the whole of our current literature.

Every bit of literature up to the middle of the 15th century existed in the form of manuscripts. These were copied by scholars who desired to possess them, or by copyists who made such reproduction their special work. The manuscripts were longer or shorter, but similar in general form. Those that were highly valued were often "illuminated," showing great care and ornamentation. But with every reproduction variations crept in, so that where several manuscript copies of a work exist no two are exactly alike. From errors thus introduced and perpetuated, the works of Hippocrates and Galen suffered, as well as from their own limitations of knowledge and experience.

With the advent of printing this was changed; the mechanical process gave any desired number of copies, each an exact reproduction of the others. Manuscripts became valuable, chiefly as relics. The handwriting of a great man, or the early manuscript of an important work showing elisions, emendations and corrections, still has some value; but for purposes of a scientific literature is quite inferior to the printed copy. The printed form at first followed the manuscript. The letters used resembled those made by the pen, the ornamentation caused the use of initial letters; and a title page of highly ornamental letters, sometimes printed in two colors. The protective cover of the manuscript was transformed into the binding of the book. The early issues from the printing press took the form of books. Only as the wide dissemination of writings became more important than their preservation, was the cover or binding dispensed with and the pamphlet form adopted.

Journals. At first each pamphlet was an independent publication devoted to one subject. Only after two hundred years of printing was the successive issue, at more or less regular intervals, of pamphlets similar in size and form, but devoted to different matters—the journal form of literature—established. The newspaper had come into existence early in the 17th century, and in 1665 the British Royal Society began to publish volumes of its *Philosophical Transactions.* But it was near the close of the 18th century before the medical journal in its present form appeared.

The first ophthalmic journal issued was the *Ophthalmologische*

Bibliothek, of which three volumes were published, under Carl Himly and Johann A. Schmidt from 1802 to 1807, and two more were issued by Himly in 1816 to 1819. Next came the *Journal der Chirurgie und Augenheilkunde*, edited by Carl Ferdinand von Graefe and Ph.F. von Walther. This ran to thirty volumes between 1820 and 1840; and nine more volumes were edited by Walther and Frederick August von Ammon between 1843 and 1850. The *Monatschrift für Medicin. Augenheilkunde und Chirurgie* was also edited by von Ammon from 1836 to 1840. In 1836 Richard Middlemore (1803-1891) proposed to publish an ophthalmic journal, and issued a prospectus setting forth his plans, but the journal was not published. Pansier states that an *Archives d'Ophtalmologie* was published by Jamain in 1853-55. In 1858 Borelli started the *Giornale di Ottalmologia Italiano,* but it seems not to be represented in American libraries.

In July, 1862, was issued in New York the first number of the *American Journal of Ophthalmology*, edited by Julius Homberger. It was bi-monthly and completed one volume and part of the second; but ceased to exist in 1863. A journal called the *Ophthalmic Review,* a quarterly, was started in 1862 by J. Zachariah Laurence, of London, and Thomas Windsor, of Manchester. It was published semi-annually for about six years (three volumes). The *Recueil d'Ophtalmologie,* established in 1873 by X. Galezowski, was issued monthly, being continued by Jean Galezowski until 1911. The *Bollettino d'Oculistica* was started by Andrea Simi in 1878, and continued to 1904. *Die Ophthalmologische Klinik*, established by Königshöfer and Zimmermann in 1897, was a German edition of *La Clinique Ophtalmologique.* From 1880 to 1885 Albrecht Nagel published *Mittheilungen aus der Ophthalmiatrischen Klinik* in Tübingen. E. Hansen Grut, J. Bjerrum and J. Widmark issued the *Nordisk Ophthalmologisk Tidsskrift* in Copenhagen from 1888 to 1892. *The Journal of the Eye, Ear, Nose and Throat*, edited by F. M. Chisolm and J. Winslow, was published in Baltimore from 1896 to 1900.

The following are known to have been published, but details regarding them are lacking: H. Armaignac at Bordeaux published about 1879 the *Révue Clinique d'Oculistique du Sud-Ouest.* About 1877 Badal published at Paris the *Bulletin Mensuel de la Clinique.* The *Pratica Oculistica* was published at Rome about 1910. At Naples, 1878, F. Morano issued a *Giornale delle Malattie degli Occhi.* In Spain, about 1885, D. Cayetano del Toro of Cadiz, published *La Cronica Oftalmologica*, and at Madrid about the same time A. de la Penna issued *La Oftalmologia Pratica.* In Portugal F. L. de Fonseca and van der Laan started, 1878-1880, jointly, the *Periodico de Ophthalm.*

Practica, and, separately, a *Periodico de Ophthalmo. ed Pelo,* and the *Archivo Ophthalmotherapico,* all of Lisbon. *Mittheilungen aus der Augenklinik des Carolinischen Medico-Chirurgischen Institut* of Stockholm were published, from time to time, at Jena. The *Mittheilungen der Inouye'schen Ophthalmolgischen Gesellschaft* was published at Tokyo before 1898.

The ophthalmic journals that were being published in 1914 at the outbreak of the war are given in the following table, arranged chronologically under the countries in which they were published.

AMERICA

1869 *The Archives of Ophthalmology* was started as the *Archives of Ophthalmology and Otology* by Herman Knapp, of New York, and S. Moos, of Heidelberg, being published simultaneously in German. After volume 7 it was divided into the *Archives of Ophthalmology* and the *Archives of Otology.* At first it was published semi-annually, then quarterly, and from 1898 bimonthly, one volume per year.

1884 *The American Journal of Ophthalmology,* edited by Adolf Alt, is published in St. Louis, monthly, one volume per year.

1889 *The Journal of Ophthalmology, Otology and Laryngology* was established in New York by Charles H. Norton and Charles Deady, quarterly. After a period of suspension it was edited by J. L. Moffat and published monthly. It is now edited by George W. MacKenzie, of Philadelphia.

1891 *Annals of Ophthalmology* was established as the *Annals of Ophthalmology and Otology* by James Pleasant Parker, of St. Louis. In 1897, volume six became simply the *Annals of Ophthalmology.* It has always been issued quarterly. After the death of Dr. Parker in 1896 the managing editors have been Casey A. Wood to 1899; H. V. Würdemann to 1904; James Moores Ball to 1906; W. T. Shoemaker to 1912, and Meyer Wiener and Clarence Loeb since 1912.

1891 *The Ophthalmic Record* was established by Giles G. Savage, Nashville, Tenn. In 1897 it was removed to Chicago, and Casey A. Wood became managing editor; published monthly.

1900 *Anales de Oftalmologia,* monthly, was established in Mexico City, by M. Uribe y Troncoso, who continued its publication until 1915.

1904 *Ophthalmology,* a quarterly, was established by H. V. Würdemann of Milwaukee. In 1911 it was removed to Seattle, but has continued regular publication under the same management.

1907 *The Journal of Ophthalmology and Oto-Laryngology* was established in Chicago by Willis O. Nance and Albert H. Andrews. It is published monthly.

1911 *Ophthalmic Literature* was established in Denver by Edward Jackson.

1913 *Bolletino de la Sociedad Oftalmologia de Buenos Aires* is published annually for the Society.

BRITISH EMPIRE

1857 *The Royal London Ophthalmic Hospital Reports* was established by the Staff of the Royal London Ophthalmic Hospital at Moorefields. The numbers varied in size and appeared at irregular intervals. Volume 20 was completed in 1916, when this was merged with other journals to form the *British Journal of Ophthalmology.*

1881 *The Ophthalmic Review* was established by Karl Grossmann of Liverpool, and Priestley Smith, of Birmingham, and published at London at the close of the year 1881; the first volume is counted as belonging to 1882. It continued, monthly, under the editorial management of these gentlemen and their successors, Norman MacLehose and J. B. Lawford, until 1916, when it joined in the merger above mentioned.

1904 *The Ophthalmoscope* was founded by Sydney Stephenson in London. It was published monthly until 1916, when it joined in the combination above mentioned.

1917 *The British Journal of Ophthalmology*, monthly, was formed by the merger of the above journals under the editorial management of Sydney Stephenson, London.

FRANCE

1838 *Annales d'Oculistique* is the oldest ophthalmic journal that still survives. This was begun August 1st, 1838, as the *Annales d'Oculistique et Gynecologie*, by Florent Cunier (1812-1853), and M. Schoenfeld. The pages were printed in double column, and each column numbered a page. Next year the form was changed to the present one, and it became simply the *Annales d'Oculistique* under the management of Cunier. It has been issued monthly and has now reached its 154th volume, two volumes being published each year.

1878 *Recueil d'Ophtalmologie* was established in Paris by X. Galezowski. It was published monthly and was continued by Jean Galezowski until 1911.

1880 *Archives d'Ophtalmologic,* Paris, was established by P. Panas, F. Landolt, and F. Poncet. Published monthly. Now edited by F. de Lapersonne, E. Landolt, Badal, and F. Lagrange.

1882 *Revue Génerale d'Ophtalmologie,* established by Henri Dor, of Lyons and E. Meyer, of Paris. Published monthly at Paris. Continued by L. Dor, of Lyons, E. Rollet, Lyons, and H. Truc, Montpelier.

1895 *La Clinique Ophtalmologique,* Paris, established by R. Jocqs and A. Darier, later also by L. Dor. Was for a time published bi-weekly; but later monthly.

1903 *L'Ophtalmolgie Provinciale,* Tours, monthly, established by E. Motais. After his death in 1913 it was continued by Dr. Cosse.

1907 *Revue Internationale d'Hygiène et de Thérapeutique Oculaires* was established by A. LePrince, of Bourges. Monthly.

GERMANY AND AUSTRIA-HUNGARY

1854 *Graefe's Archiv für Ophthalmologie* was founded by Albrecht von Graefe, of Berlin, who later associated with himself F. von Arlt, F. C. Donders, Th. Leber, E. Fuchs, H. Snellen, H. Sattler, and A. Wagenmann. One volume was issued each year until 1888; since that time more frequently.

1863 *The Klinische Monatsblätter für Augenheilkunde,* monthly, was started by W. Zehender. It has been edited by Th. Axenfeld and W. Uhthoff since 1900.

1869 *Archiv für Augenheilkunde* the German edition of the *Archives of Ophthalmology,* edited by H. Knapp, L. Mauthner, C. Schweigger and C. Hess, published at Wiesbaden; first semi-annually, later at shorter intervals. Volume 80 was completed in 1916.

1877 *Centralblätt für praktische Augenheilkunde,* Berlin, monthly, was established and continued by Julius Hirschberg.

1890 *Beiträge zür Augenheilkunde,* Hamburg, edited by R. Deutschmann, issued in parts at irregular intervals, Heft 90, July, 1915.

1895 *Ungarische Beiträge zür Augenheilkunde,* published at Leipsic.

1896 *Sammlung Zwangloser Abhandlungen aus dem Gebiete der Augenheilkunde,* begun by A. Vossius in 1896. Volume 10 appeared in 1916.

1897 *Wochenschrift für Therapie und Hygiene des Auges,* Dresden, bi-weekly, established by Wolffberg, of Breslau.

1899 *Zeitschrift für Augenheilkunde,* monthly, established by H. Kuhnt, of Königsberg and von Michel, of Würzburg. Two volumes a year.

1911 *Archiv für Vergleichende Ophthalmologie,* quarterly, established by C. Freytag.

1913 *Zeitschrift für Ophthalmologische Optik,* quarterly, established by O. Henker.

ITALY

1871 *Annali di Ottalmologia,* established by A. Quaglino at Pavia, was subsequently edited by L. Guaita and R. Rampoldi. Volume 44 was published in 1915. It combined with *Clinica Oculistica;* and continued, 1917, as the *Annali di Ottalmologia e Clinica Oculistica,* edited by S. Cirincione and R. Rampoldi.

1893 *Archivio di Ottalmologia,* Naples, monthly, edited by Arnaldo Angelucci.

1900 *Clinica Oculistica,* Rome, established by S. Cirincione. Completed volume 15, 1915, and combined as stated above.

1905 *Progresso Ottalmologico,* established by C. Addario.

1905 *Rivista Italiana di Ottalmologia,* established in Rome by O. Parisotti.

SPAIN

1901 *Archivos de Oftalmologia Hispano-Americanos,* founded by M. Menacho, Barcelona, Spain, and J. Santos Fernandez, Havana Cuba. Monthly, published in Barcelona.

1915 *España Oftalmologica,* bi-monthly, published in Malaga, later in Cadiz, established by J. de Arana, Quintana and S. Diaz Rodriguez.

HOLLAND

1858 *Oogheelkundige Verslagen en Bijbladen* intgegeven met. Het Jaarverslag Van Het Nederlandisch Gasthuis Voor Ooglijders Utrecht 1907. First annual volume parts No. 6, 1858, to January 1, 1860.

JAPAN

1897 *Nippon Gankwa Gakuwai Zasshi,* Tokyo. Journal of the Japanese Society of Ophthalmologists.

1906 *Gankwa Rinjo Iho, Ophthalmic Clinico-Medical News,* Nos. 9-11.

RUSSIA

1889 *Vestnik Oftalmologii,* edited by V. Khodin and A. Kryukoff.

1899 *Postep Okulistyczny,* Polish, edited by B. Wicherkiewicz, Krakow.

Various hospital reports are published annually, but except the two given in the above list (London and Utrecht) can scarcely be regarded as ophthalmic journals, or of enough importance to call for mention in this brief account of the literature.

The *Transactions of Ophthalmological Societies* constitute an increasingly important part of current ophthalmic literature. A short account of these follows:

1857 The first International Ophthalmological Society was held in this year. These congresses have been held periodically and in different countries. The papers and discussions are published in the official languages of the Congress, which vary with its location. The 12th Congress was to have been held in Petrograd in August, 1914, and a portion of the papers to have been read there were published before the outbreak of the war.

1863 The *Ophthalmologische Gesellschaft* generally meets in Heidelberg, except once in four years when its sessions merge in those of the International Congress of Ophthalmology. Its Transactions have reached volume 39, 1914.

1864 The American Ophthalmological Society was formed and began to publish its *Transactions* in 1865. These are published in parts, several being paged together to form a volume. The *Transactions* for 1916 completed volume 14.

1880 The Ophthalmological Society of the United Kingdom of Great Britain and Ireland began to publish its *Transactions.* Volume 36 appeared in 1916.

1883 The Société d'Ophtalmologie Française was organized and began to publish Transactions (*Bulletins*), which reached volume 31 in 1914.

1891 The Section on Ophthalmology of the American Medical Association, which had been established 12 years before, began to publish its *Transactions* in a separate volume, this publication being continued annually since that date.

1895 The Société Belge d'Ophtalmologie published its *Bulletins* in parts; No. 36 in 1913.

1903 The American Academy of Ophthalmology and Oto-Laryngology began to publish an annual volume of *Transactions.*

1915 The Ophthalmological Society of Egypt published a Bulletin in English, French and Arabic.

Other national and local ophthalmological societies regularly publish transactions through the pages of ophthalmological journals.

Year-books and annual reviews of ophthalmology have become an important key to its literature. Between 1840 and 1845, three 12mo.

volumes were published as a supplement to the *Annales d'Oculistique*, giving a review of the current ophthalmic literature. Previous to that time, and since, such literature has received more or less notice in the existing year-books of medicine and surgery.

The next attempt to collect ophthalmic literature into a single volume was made when Nagel published in 1872, a review of the literature of ophthalmology for the year 1870 in his *Jahresbericht über die Leistungen und Fortschritte im Gebiete der Ophthalmologie*. At Nagel's death Julius Michel took up the editing of this book and continued it until his own death in 1911.

In 1882 Henri Dor and Edward Meyer began to publish the *Révue Générale d'Ophtalmologie*. This appeared monthly; but it undertook to bring together abstracts of the world's ophthalmic literature. It was continued until 1914.

In 1899, *Progressive Medicine*, a quarterly digest of medical science, began to be published. Volume 2, June, for each year contains a review of important advances in ophthalmology, by Edward Jackson.

In 1901 The *Practical Medicine Series* was begun. It consists of ten small volumes, issued each year, of which volume 3 is devoted to the eye, ear, nose and throat. The portion devoted to the eye is edited by Casey A. Wood.

The *Ophthalmic Year Book* was begun by Edward Jackson in 1904. It is intended to furnish a digest and bibliography of all papers important to the ophthalmologist, to be found in the literature of the world.

. Many ophthalmic journals give from time to time lists of papers on ophthalmic subjects appearing in other journals. In 1880 Dr. John S. Billings, in charge of the Library of the Surgeon-General, at Washington, began to supply an index to the medical literature of the world, the *Index Medicus*. This periodical has always contained a department devoted to ophthalmology. Including three years, during which period it was published in French, this work has continued to the present time.

In 1911 a similar index of ophthalmology was started in *Ophthalmic Literature*, published monthly.

Systems and Encyclopedias. When the monograph had won its place in the literature of ophthalmology, and specialization in authorship was recognized, no one writer was considered the highest authority on all subjects, and a system of joint-authorship was a natural development that marked the literature of the second half of the 19th century. The *Handbuch der Gesammten Augenheilkunde,* Alfred Graefe and Theodore Saemisch, is the most striking illustration of this class of

literature. It was issued in seven volumes between 1874 and 1880, representing the work of 24 collaborators. A second edition, edited by Saemisch, was started in 1899. It has run to 14 volumes but has never been completed. Different parts being sold separately some have been sold out; and a third edition has been partly published.

In France the *Traité Complet d'Ophtalmologie*, edited by L. de Wecker and E. Landolt, was published in five volumes, 1880-1889. Each volume represented the work of several collaborators. In America a four-volume "*System of Diseases of the Eye*" was edited by Wm. F. Norris and Charles A. Oliver, and published 1897 to 1900. It was written by 59 authors of whom 31 were American and 28 European. Other books on the same plan, published in America, have combined ophthalmology with otology and laryngology, as those of G. E. de Schweinitz and B. A. Randall; of W. C. Posey and J. A. Wright; also *The Eye and the Nervous System*, by Posey and Spiller. In Great Britain no such "system" of ophthalmology has appeared.

A work called the *Encyclopédie d'Ophtalmologie*, embracing 9 volumes of 800 to 1100 pages each, edited by F. Lagrange and E. Valude, was published in Paris from 1903 to 1912. It is, however, simply a "system" or collection of monographs, each volume being the work of several authors, each developing his particular subject with a certain approach to completeness. In this class of works should also be mentioned *Die Neurologie des Auges*, by H. Wilbrand and A. Saenger, of Hamburg. It began to appear in 1900, has now reached its sixth volume, and is designed to be completed in seven volumes.

In 1800 M. Wenzel published in Paris what he called *Manuel d'Oculistique ou Dictionnaire Ophtalmologique*. It was in two volumes comprising 825 pages with 24 plates. The text was arranged under topic headings, placed alphabetically as in the ordinary dictionary; but the length of the articles (53 pages on cataract) entitles it to be classed as an encyclopedia, the first work of the kind dealing with ophthalmology. In 1902 was begun in Leipsic the publication of the *Encyclopedie der Augenheilkunde* under the editorship of O. Schwarz and 53 German confreres. It was arranged upon the true dictionary or encyclopedia plan, and issued in parts, of which 18, comprising 848 pages, carrying the work to "Sympathicus," had been issued in 1909; but it seems never to have been completed. These are the true predecessors of this *Encyclopedia*; the other so-called dictionaries of ophthalmology are small and unimportant.

The history of ophthalmology and the biographies of ophthalmologists by T. H. Shastid for this *Encyclopedia*, make it unneces-

sary to trace the history of the literature in different countries, or languages. As Pansier points out, there has always been a healthy internationalism in the literature of science. However, a brief review of the early literature of *ophthalmology in America,* may be of some service.

1825 The first book on ophthalmology written and published in America was *A Treatise on the Diseases of the Eye,* by George Frick of Baltimore (see Vol. VII, p. 5294, of this *Encyclopedia*). It was an octavo of 340 pages with one plate, and was copyrighted July 2nd, 1823. In 1826 an edition, edited by Richard Wellbank, was published in London.

1832 John Mason Gibson published a quarto of 216 pages and 10 plates, but without an index.

1836 The first of W. C. Wallace's books appeared, but these belong rather to popular than to scientific ophthalmic literature.

1837 S. Littell, of Philadelphia, published a *Manual of Diseases of the Eye,* a duodecimo of 269 pages (See Vol. X, page 7500 of this *Encyclopedia*).

1841-1845 The books on strabismus have been noticed above.

1850 The work of Howard published in Montreal (see Vol. VII, p. 6056 of this *Encyclopedia*) is of historic interest on account of the list he gives of subscribers for the work; including, with those interested chiefly in the author, those who were at that time especially interested in its subject.

In the second half of the 19th century the literature of ophthalmology in America made enormous strides. The more important treatises of English authors were edited by American writers, and republished in America in large numbers. But before the close of the century they had been largely replaced by works of American authorship. The journals established and transactions issued have been adequately noticed elsewhere. Mention of the more important monographs will be found in this *Encyclopedia* under appropriate captions.

Illustrations. Literature began in picture-writing; and when hieroglyphics had developed into an alphabet, text and picture were never wholly divorced. The manuscripts of the middle ages were elaborately illuminated, and development of the modern illustration of books was practically coincident with that of printing. Line engraving on copper was used in the 15th century. Vesalius (1514-1564) employed wood-cuts, drawn from dissections, to illustrate his anatomical works. The books of Zinn and Soemmering were notable for their copperplate illustrations, the former having seven, the latter eighteen plates. The work of Porterfield was also well illustrated with line engravings

on eight plates. Soon surgical instruments and the manner of using them were added to the anatomic plates and optical diagrams, as in the works of Bartisch and Daviel. In the 19th century both lithography and photography were brought to the service of the illustrator, lending themselves better than the older processes to the reproduction of clinical pictures. The number of illustrations based upon photography is rapidly increasing in books and journals of the present time.

The greatest triumphs of color lithography are seen in the atlases of the 19th century. In 1838 von Ammon published in Berlin his *Klinische Darstellungen der Krankheiten des Menschlichen Auges.* This was a folio in two parts, including 98 pages of text and 35 plates, with 687 figures, mostly in colors. A third part, published in 1841, includes 90 pages of text and 20 plates with 201 figures. Less comprehensive than the work of von Ammon, yet equally valuable, and having even more beautiful illustrations, is the *Pathology of the Human Eye*, by John Dalrymple, published in London in 1852. It is a large quarto with thirty plates. The atlas, *Pathologische Topographie des Auges* of Otto Becker, having about 100 pages of text and 30 plates, was published in 1874 to 1878. Since that time the atlases of Haab, Greeff and Ramsay have set forth the appearances of external diseases of the eye.

The first important atlas based on photography was that of Edouard Meyer, on *Operations on the Eyeball*, illustrated by 24 photographic plates, published in 1871.

The ophthalmoscope revealed such striking and significant appearances, that those who observed them soon wished to place upon record and reproduce them for teaching. From the time it was introduced the principal atlases have been devoted to ophthalmoscopy. In Sichel's *Iconographie Ophtalmologique* (1852-59), 3 of its 80 plates are devoted to the ophthalmoscopic conditions. The leading worker in this field of ophthalmoscopic reproduction was Eduard von Jaeger, of Vienna. One of the plates produced by him is said to have cost him 200 hours of labor. In his large quarto *Pathologie des Auges* (2nd edition 1870), which ran to three editions, are 73 of these colored lithographic plates. In his smaller *Hand-Atlas* are 29 plates, giving 128 different colored representations of the fundus oculi. The atlas of Richard Liebreich (1870) is the result of years devoted to the study of pigments and processes, by which ophthalmoscopic appearances could be best reproduced. Other important ophthalmoscopic atlases are those of Frost (1896), Oeller (1896), Magnus (1892), Haab (1899), Curt Adam (1912), Lindsay Johnson (1897). The

last writer has given us an atlas of the comparative ophthalmoscopy of mammals. The latest book of this kind is by Casey A. Wood (1917), *The Fundus Oculi of Birds.* The reproduction of microscopic appearances by lithography and photography has also furnished in this monograph an important adjunct to the text describing them.

In this connection must also be mentioned *Diagnostics of the Fundus Oculi* (1913) by Edward L. Oatman. This is supplied with 78 colored plates, reproduced by photography, for use in the stereoscope.

How to use ophthalmic literature to the best advantage is a subject for the careful consideration of every one who reads it. Although it cannot in any way replace the need for skilled observation and careful thought, it can prove of the greatest value in stimulating and furnishing material for these essential actions. The careful arrangement and classification of such literature and a good method in its use are essential.

Arrangement and classification should be carefully attended to in every book, monograph or journal article that is produced. In a general way this arrangement of matter should be the one commonly followed. In writing on a single disease, etiology, clinical course, and characteristics, pathologic findings, and comparison with other literature on the subject or related subjects, are commonly considered in much the order named. In text-books and systems it is customary to devote successive chapters to classes of diseases grouped by the structures they affect, as: diseases of the lids, diseases of the lachrymal apparatus, etc. When one is familiar with the system of grouping it becomes easy to find the statement sought. It is commonly time well spent, on picking up a new book or journal, to look first at its table of contents and see how it conforms to the usual arrangement of such books, or what its peculiarities are.

In attempting to trace and study the literature of a particular topic it is well to begin with the later articles or treatises upon it, in which will be gathered together more or less of the thought or observation of all preceding writers. If the paper has a good bibliography it at once brings the reader in touch with the more important parts of the preceding articles upon the topic; and these used in the same way will in turn reveal some others not before known. Generally as one extends the search the number and importance of the new finds progressively diminishes.

To make the start in looking up the literature of a special topic, one goes to the year-books, or *indexes* to learn the latest papers upon it. If he wishes to make a thorough search of all the files of a certain journal he must go carefully over the indexes, noticing not only the

topic or word under which he would first expect to find what was wanted; but also the other titles under which it might be found. In such an undertaking a good index is of enormous value. Some journals are supplied with indexes, covering all their volumes through a series of years. These are particularly helpful for bibliographic research. It is fortunate that the value of a good and comprehensive index is coming to be appreciated more and more.

Libraries, where everything is available through arrangement and cataloging, are of the highest value as a means to research in the literature. Almost all the important public collections of ophthalmic literature are departments of general medical libraries. An exception has been the library of the Ophthalmological Society of the United Kingdom of Great Britain and Ireland, at London. In America the most important collections are the Library of the Surgeon-General at Washington, D. C., The College of Physicians of Philadelphia, The New York Academy of Medicine, which has the best collection of ophthalmic journals, The Boston Medical Library, The John Crerar Library, of Chicago, and the Casey A. Wood Collection of McGill University at Montreal. But other extremely valuable collections of books on ophthalmology are rapidly accumulating and should be fostered and supported.

Catalogues are required for every important collection of books; the most important are of authors, topics, and titles. Sometimes although the general topic is known the exact title of the book or paper sought is not known. In such case the list of authors may be of great service.

For use in the library, the card catalogue is of the highest value. It can be kept constantly up to the latest additions; and all serviceable details can be included on the cards. Each card catalogue is constructed especially for the library it is to serve. There also is use for printed catalogues available away from the library. Of these there are very few. The best is the "Index Catalog of the Library of the Surgeon-General's Office" now available in most medical libraries. J. Hirschberg published in 1901 a catalogue of his own library of medical history and ophthalmology, which includes about 400 pages devoted to the latter topic. He donated this collection to the library of Berliner Chirurgische Gesellschaft. A catalogue of the library of the Ophthalmological Society of the United Kingdom, comprising 92 pages, was published in 1899. In general, however, the function of a printed catalogue must be performed by the lists found in the year books, the index of ophthalmology in *Ophthalmic Literature* or the *Index Medicus*, which have the advantage of being always closely up to date.

Bibliographies are a most valuable part of the literature of ophthalmology. As given with papers and monographs they serve the purpose of indexes or catalogues for the literature of the particular topic to which they refer. Some books, as for instance, *The Diseases of the Eye*, by William Mackenzie, are of permanent value chiefly because they furnish the key to the literature of a period. An admirable example of the service that may be rendered by a bibliography is that offered by the one appended to *The Muscles of the Eye* by Lucien Howe. *Die Neurologie des Auges* of Wilbrand and Saenger has enormously greater permanent value, because of the bibliography appended to each section. The value of this kind of literature depends on two things, accuracy and completeness. If it have these two virtues the bibliography of the most limited subject becomes important. Even an accurate list of the writings of a single author, like that of the contributions of George M. Gould (1909), may be of real and lasting service.—(E. J.)

Ophthalmology, Veterinary. That branch of science that deals with the physiology and pathology of lower animal eyes. See **Veterinary ophthalmology.**

Ophthalmolyma. (L.) (Obs.) Deterioration or destruction of the eyeball.

Ophthalmomacrosis. An obsolete or disused term for buphthalmos or enlargement of the eyeball.

Ophthalmomalacia. Wasting of the eye; a condition, independent of any apparent inflammatory process and mainly characterized by atrophy (phthisis bulbi), diminished tension and decrease in size of the eyeball. When of this character it is sometimes called *essential* ophthalmomalacia.

Ophthalmomalacia intermittens. A form of ophthalmomalacia in which diminution of tension appears suddenly, remains for a few hours or days, and then disappears, to reappear again and again at irregular intervals.

Ophthalmomalacia simplex. A form of ophthalmomalacia in which the diminution of tension and size of the eyeball is very chronic or remains unchanged for a length of time.

Ophthalmomanometer. This instrument in the hands of E. B. Coburn (*Annals of Ophthal.*, July, 1908) has proven to be a most excellent means of determining the ocular tension.

He points out that with the single exception of the tonometer of Maklakoff, these instruments depend for their measurements upon weighted levers or springs and their readings are recorded on em-

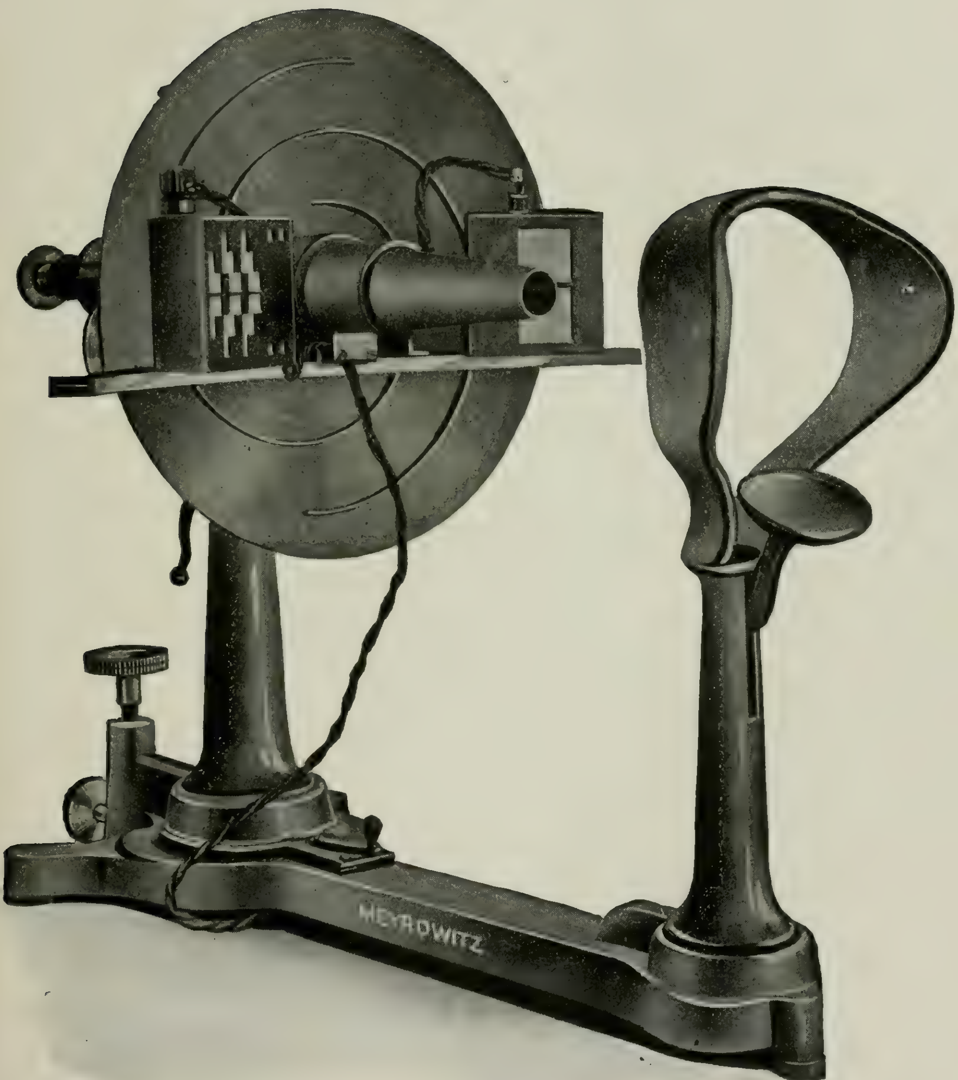
pirical scales, and, if comparison is desired, with intraocular manometric determinations, the relations of these scales must be evaluated.

Coburn's instrument is more accurate than most tonometers because applantation can be positively determined, and as the readings are made on a mercury manometer the values are absolute and not relative. The apparatus consists of a glass tube about 6 mm. in diameter but drawn down to about 1 mm. in the center and to about 3 or 4 mm. at one end. This is protected by a fenestrated brass sleeve, through the opening in which the constricted part of the tube can be seen, and in which a sliding marker, pointing towards the capillary tube, is placed. The wider end of the tube is covered with a thin rubber membrane while the other end is connected by a rubber tube to a mercurial manometer. From the middle of the rubber tube a lateral branch leads to a rubber ball.

The method of using it is as follows: The glass tube is filled to the lower end of the constricted part with colored water. The diaphragm closing its end is pressed against a flat surface and the indicator moved so as to mark the top of the fluid in the tube when the diaphragm is plane. The diaphragm is applied to the eye with just sufficient force to barely dimple the surface of the ocular tissues. As the diaphragm is thus pushed inwards the fluid rises in the capillary tube. Pressure is now made on the rubber ball until the fluid returns to its original level as marked by the indicator, and then the manometric reading is taken. The pressure as shown by the manometer indicates the ocular tension. Corrections may be made for the elasticity of the rubber diaphragm and the weight of the water indicator, but these are very small and may be neglected when only relative results are required. See, also, **Tonometer**; also p. 7595, Vol. X of this *Encyclopedia*.

Ophthalmomanometry. Measurement of the intraocular pressure by means of a manometer. See p. 7595, Vol. X of this *Encyclopedia*. See, also, **Ophthalmomanometer.**

Ophthalmometer. Keratometer. Astigmometer. This subject has already been treated on p. 4709, Vol. VI of this *Encyclopedia*, and to some further extent under other captions. In addition it may here be said that Kagenaar, Brudzewski (Tscherning's *Physiological Optics*, p. 59), Sutcliffe (*Ophthalmic Record*, Mar., 1908) and a number of others (opticians, physiologists, ophthalmologists) have designed models, parts of which are now represented in the latest and most efficient instruments. It must be remembered, however, in all these corneal astigmometers that the readings of the instrument are only approximate so far as regards the strength of the lens indicated for



The Javal-Schiötz Ophthalmometer.

the neutralization of the total astigmatism, although the indicated axis is almost invariably correct.

It is well to remind the reader, both by reference to the accompanying illustration and by quotation from the following text, that the original Javal-Schiötz ophthalmometer still holds its place among instruments for measuring the total *corneal* astigmatism which, as is well known, is uniformly less than the total astigmatism of the human dioptric apparatus.

The optical system of the Javal-Schiötz ophthalmometer includes a Wollaston bi-refringent quartz prism and achromatic objectives. The targets or *mires* are the parallelogram and steps devised by Javal and Schiötz years ago. In spite of numerous experiments with other

The Javal-Schiötz Ophthalmometer.

forms, no better mire has been devised. This mire is particularly sensitive in determining the continuity, or lack of it, of the central black line.

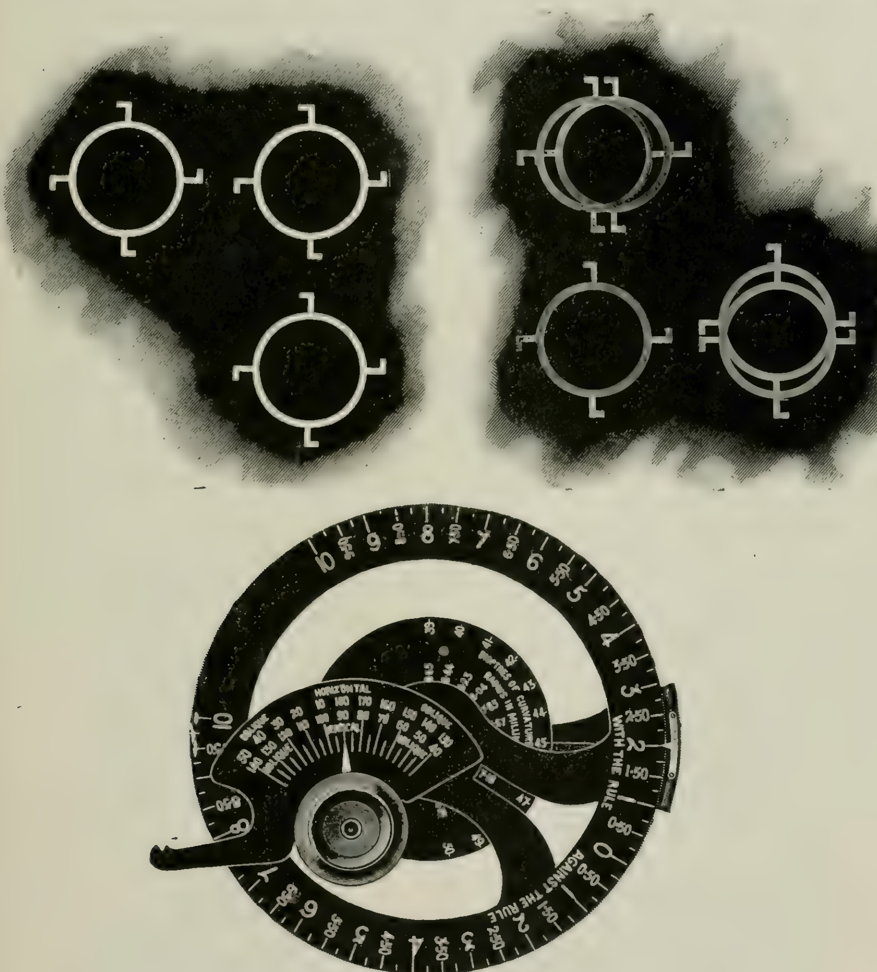
The telescope (see the illustration) is supported in a sleeve at the upper end of the column in which it may be racked back and forth for focussing by means of a milled wheel at side.

The *telescope* is raised or lowered to bring it to the level of the patient's eye by means of a lever concealed in the base and operated by the milled wheel and vertical shaft placed near the end of the instrument.

The *chin-rest* of rubber enamelled covered metal is raised and lowered by means of a horizontal shaft, and can be operated from the examiner's end of the instrument.

The mires are controlled through an entirely new method, original in this instrument. The large dial is made to revolve independently

of the telescope and arc, and has mounted on its concave face two spiral tracks. On the back of each of the mire boxes is a groove-like attachment engaging one of these spiral tracks. As the dial is revolved, therefore, the mires, following the spiral, are moved along the arc to



The Sutcliffe Keratometer, showing also the Form of the Mires.

or from the center, according to the direction of the rotation of the dial. Small posts are mounted at short intervals near the periphery of the dial on its convex side so that it may be conveniently revolved from any point—the operator is relieved of the necessity of visually locating this control.

From the outer scale is obtained the *amount of astigmatism in diopters.* It is graduated to quarter diopters. Two pointers (with double oval openings) are provided, one of them indicating the focus of the primary position, the other one the focus of the secondary position, the difference being the astigmatism. The primary pointer is stationary with regard to the scale. It does not change its reading unless moved by hand. The secondary pointer changes its reading with every movement of the mires.

The inner circle shows the *axis scale.* The small pointer moves with the telescope and records the position of the mires.

In Sutcliffe's *keratometer* there is but one mire. Once the axis is found there is no rotating to a second position. When the focus and axis are determined the instrument automatically gives a reading on scales. G. Young (*Practical Medicine Series, Eye,* p. 179, 1911) has compared the instrument with that of Javal in 60 cases and found it to be just as accurate as that instrument.

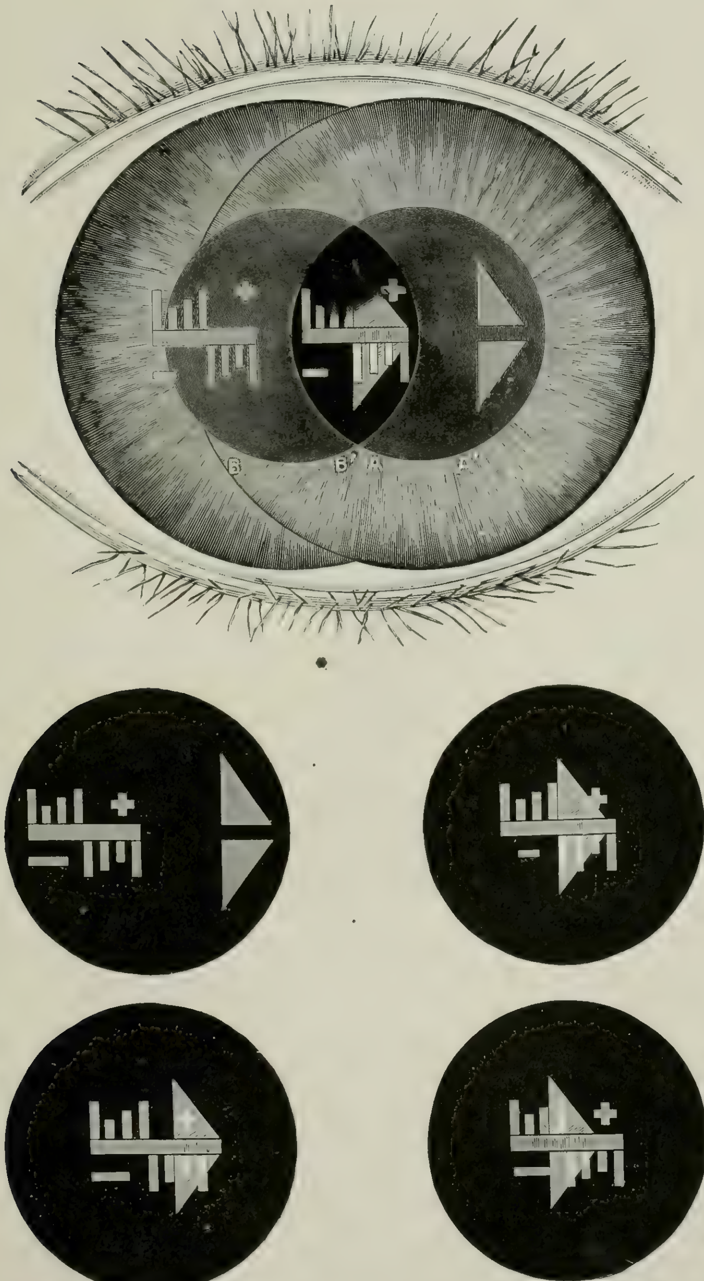
In Hardy's improved ophthalmometer the targets, reflectors or mires, one of which is triangular shaped, is bisected by a black space, the other being arranged in steps and spaces on either side of a longitudinal white space, are fixed on the large disc at a certain distance apart, are stationary, and are in the same plane as the deviation of the birefringent prism. They are translucent and are illuminated from behind by incandescent lamps, contained within cups on the back of the large disc, thus shutting out the light from the eyes of the operator and avoiding the heat generated by large lamps. They may also be sufficiently illuminated by daylight if the instrument is placed near to and facing a window.

This method of electric illumination and the shape of the mires, which are peculiarily adapted to the purpose, together with superior lenses and biprism, give a clearness and perfection of definition which enable the observer to locate the principal meridians accurately and to read a quarter of a diopter of astigmatism with exactness. (See the cuts.)

The Bausch and Lomb keratometer differs from other models.

The accompanying figure represents a longitudinal section of the optical arrangement of the keratometer constructed in this manner; F indicates the principal focus of the plano-convex lens with a power of + 6.00 D, the principal focus appearing within the plane of the aperture of the diaphragm through which the observer is looking; m represents the scale in the keratometer, marked in millimeters; °1, °2, objects appearing within the parallel beam of light, 0.

When an instrument is constructed on this principle and an obser-



The Targets or Mires of the Hardy Ophthalmometer.

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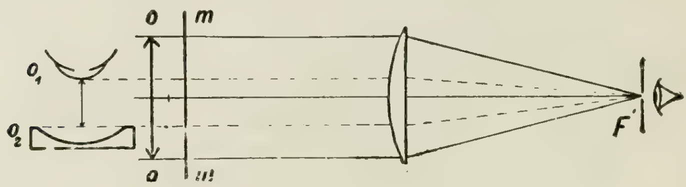
*NOTE.—The amount of the overlapping and the proportionate size of the images are exaggerated for the purpose of clear illustration.

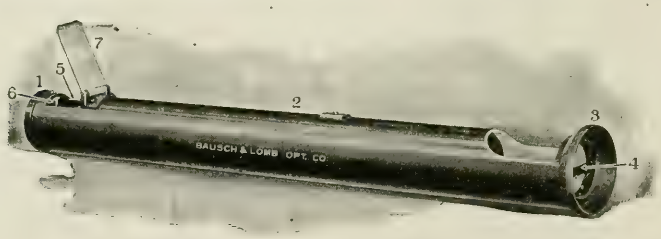
vation is made through the ocular diaphragm situated in the posterior focal plane of the lens, as shown in the illustration, it follows that the rays proceeding from the object to the lens will be parallel to its axis. If now a scale be placed in front of the object, as indicated



Bausch and Lomb Keratometer.

between the letters m, a correct reading of the size of the object will be obtained regardless of its position, and the parallax noticeable when an object is measured with an ordinary rule (the rule, however, not being in exactly the same plane as the object) is entirely eliminated.

In the next figure an external view of the keratometer is illustrated showing the ocular diaphragm (1) which is fitted to a metal tube (2) on the one end, while on the other end an eyepiece cap (3) is situated by means of which the instrument may be rested upon the mar-



Bausch and Lomb Keratometer.

gin of the orbital cavity of the patient's eye. Within the ring of the eyepiece cap a scale (4), divided into one-half millimeters, is so mounted that its upper edge may pass accurately through the center of the ring. In front of the ring the metal tube has a large excision through which sufficient light may reach the scale and the patient's eye. The scale (4) is situated near the anterior focus of the lens, and the same applies to the cornea which is to be measured; hence both the scale and the cornea can easily be seen magnified 1.5 times by an eye in front of the ocular diaphragm (1). At the end of the tube fitted

with the ocular diaphragm an excision (5) is made to allow for the illumination of the white mark (6), which illumination may be adjusted by means of the white screen (7). The white mark (6) serves as a fixing mark for the eye of the patient under examination. It goes without saying that a cornea of any diameter may be measured with this instrument, and by rotating the apparatus the diameter of the cornea in any direction may be ascertained.

It is best steadied by the third and fourth fingers of the left hand, with which the operator holds the farthest end of the tube upon the patient's temple. In the case of bi-convex spectacle lenses there should be no difficulty in measuring the distance from apex of cornea to vertex of lens direct. With weak positive lenses or negative lenses, measurements are best taken from the apex of cornea to the surface of trial frame facing the eyes of the patient, and the distance from this trial frame to the vertex of the trial frame lens is then ascertained by an ordinary depth gauge. The two readings together then represent the entire distance from apex of cornea to vertex of trial case lens. The measurement of the vertical distance of the objects °1, °2 (shown diagrammatically in the first figure), will not fail to be correct, even though the objects are not in one plane and do not coincide with the scale, since, as explained above, the rays proceeding from the object and scale are parallel.

The so-called *new keratometer* of Spiller has, according to the makers, certain advantages. There is only one simple mire consisting of a cross enclosed in a circle, the narrow limbs of which are made to coincide with the principal meridians. The intersecting images of the circle enclose the short contact limbs, so that no confusion can arise as to what the operator must look for.

There can thus be no distortion of the image such as is found with the step or solid mire. The area of cornea utilized is moderate, and therefore peripheral variations in curvature cannot confuse the result, because it must not be forgotten that the cornea is only truly spherical or (in astigmatism) only truly toroidal over a small central area not exceeding some 3 mm. in diameter. It follows that definition in the zone occupied by the cross limbs is good with a moderate size mire, and contact easily made to the greatest nicety. In addition, the microscope gives a higher magnification than is usually employed. There is no arc and no secondary position visible to the patient. No effort of memory is demanded in the least; the axis, readings and nature of the astigmatism (with or against the rule) are simultaneously and automatically recorded. The small lever gives an exact rotation of the images through 90°, so that the observer need not remove his eye

from the microscope to secure the secondary position. On account of the translucent dial no external illuminant is required in the room. The Scheiner device ensures an absolute focus, and the slightest departure from the correct position immediately results in the "splitting" of the images. The chin-rest is abolished and for it is substituted a brow-rest. This alteration ensures a perfectly natural position of the head together with freedom to answer questions on the part of the patient.

Ophthalmometroscope. An ophthalmoscope with an attachment for measuring the refraction of the eye.

Ophthalmometry. Measurement or examination of the eye by means of the ophthalmometer.

Ophthalmomyiasis. See **Myiasis.**

Ophthalmomyitis. Ophthalmomyositis. A term used by old writers to define inflammation of the muscles of the eyeball.

Ophthalmomyositis. Inflammation of the extrinsic eye muscles.

Ophthalmomyotomy. Surgical division of the muscles of the eye.

Ophthalmoncus. (Obs.) Swelling of the eye.

Ophthalmoneuritis. Inflammation of the ophthalmic nerve.

Ophthalmoneuromyélite. (F.) A term applied by de Lapersonne to the rather rare symptom-complex accompanying the optic neuritis of myelitis, which Devic called *neuromyélite optique aiguë.* See **Myelitis**; also the same (sub) title under **Neurology of the eye.**

Ophthalmoneuromyelitis. See *Myelitis,* under **Neurology of the eye.**

Ophthalmonosology. The pathology of the eye.

Ophthalmopathy. Any disease of the eye.

Ophthalmopathy, External. An affection of the eyelids, cornea, conjunctiva, or muscles of the eye.

Ophthalmopathy, Internal. Any affection of the deep or more essential parts of the eye.

Ophthalmophakometer. Ophthalmophacometer. The ophthalmometer of Tscherning (*Optics,* p. 44) for measuring the two surfaces of the lens and the posterior surface of the cornea.

Ophthalmophantom. A model of the eye used in demonstration; or an apparatus for holding animals' eyes for operation. See **Phantom;** as well as under the section on **Operative skill in ophthalmic surgery.**

Ophthalmophlebotomy. Phlebotomy to relieve congestion of the conjunctival veins.

Ophthalmophobia. Fear of the eye. A nervous affection, in the beginning of which the patient is simply ill at ease whenever anyone is gazing at him intently. Later, he cannot bear the society of his fellow human beings, a condition not greatly dissimilar to that which

is known as *agoraphobia*, but having only this one special cause. Finally, the victim falls actually ill. Seligmann (*Kosmos*, Stuttgart, Sep. 15, 1914) declares that ophthalmophobia is, at bottom, the cause of the widely-spread superstition known as "the evil eye." He also believes that the nervous affection in question is based upon the mistaken optical theory, "once universal and still adhered to by the ignorant . . . that sight is the result of radiation proceeding from the eye to the object seen."

Seligmann divides ophthalmophobiacs into three groups. Mild ophthalmophobia includes persons who when they notice anybody looking at them, at once begin to wonder whether their hats are on straight or whether in some other way they appear peculiar. The severe type makes the sufferers perfectly miserable. If a woman is afflicted with severe ophthalmophobia, she wears a thick veil or hides her face behind a fan; a man uses a newspaper or gets into the shadow of a piece of furniture, his hands get cold, and his face perspires freely. The third section of the subject is the "evil eye." Even in Germany, a trace of this superstition is evident. Seligmann says that even "cultured" persons when praised, tap three times under the table, and say "Unberufen."—(T. H. S.) See, also, p. 4554, Vol. VI of this *Encyclopedia*.

Ophthalmophorometer. A name given by Ostwalt (*Bericht der Oph. Gesellsch.*, 1895) to his phorometer in which the Maddox prism is the chief agent in determining the kind and degree of muscle imbalance.

Ophthalmophthisis. Phthisis bulbi, or ophthalmomalacia; atrophy of the whole eyeball.

Ophthalmoplasty. Plastic surgery of the eye or of its appendages.

Ophthalmoplegia. Nuclear palsy. This form of oculomuscular paralysis is the result of a lesion affecting the nuclei of the ocular muscles in the floor of the fourth ventricle and in the aqueduct of Sylvius. The external muscles alone may be involved (external ophthalmoplegia) or the internal muscles alone (internal ophthalmoplegia), or both groups together may be affected (mixed ophthalmoplegia). It may be congenital or acquired. The acquired type appears in two forms, acute and chronic.—(J. M. B.)

See, also, the various **Ophthalmoplegia** headings; as well **Congenital anomalies.** There is also a *familial* form of the disease.

Ophthalmoplegia, Asthenic. A name given by Karplus to a form that simulates a true bulbar paralysis but in which the central lesion is lacking. It is really an exaggerated form of muscular asthenopia; or it may represent an early stage of multiple sclerosis.

Ophthalmoplegia externa. EXTERNAL OPHTHALMOPLEXIA. OPHTHALMOPLEGIA EXTERIOR. Paralysis or paresis of one or more of the orbital or external muscles of the eye. See **Muscles, Ocular**; **Tabes dorsalis**; **Syphilis of the eye**; and such other captions as **Diplopia**, p. 4006, Vol. VI of this *Encyclopedia;* also various sub-headings under **Neurology of the eye.**

Ophthalmoplegia, Fascicular. Ophthalmoplegia due to lesion in the pons varolii.

Ophthalmoplegia, Graux-Féréol type of. Associated paralysis of the muscles affecting the right internal of one side and the right external of the opposite side.

Ophthalmoplegia interna. OPHTHALMOPLEGIA INTERIOR. Paralysis of the iridic and ciliary muscles. When it is complete a central lesion is (apart from drugs and trauma) uniformly the cause.

M. Grossman (*Journ. Am. Med. Assocn.*, p. 963, Mar. 31, 1917) believes this symptom-complex to be the rarest form of pupillary disturbance found in congenital or acquired syphilis of the nervous system. It manifests itself clinically as a paralysis of the intrinsic muscles of the eye. The pupillary phenomena may be unilateral or bilateral, the unilateral being encountered about twice as frequently as the bilateral. The phenomena consist of widely dilated pupils which do not react to accommodation, convergence or light reflex. Such pupils do not contract when physostigmin or other miotics are dropped into the eye. In the syphilitic cases, the pupils are, in addition, unequal in size and irregular in outline.

This writer says: "It is of interest to note that when the pupillary activity returned in my cases, during the course of antispecific treatment, the response to physostigmin was the first to appear. This was followed by the return of the reaction to convergence, next accommodation, and last of all light reflex. The same sequence was noted in three of the patients, two of whom have almost completely recovered their pupillary reactions."

The importance of early recognition of these cases of latent congenital syphilis is evident. It is highly probable that some further involvement of the central nervous system may occur if treatment is not instituted in these cases.

Speaking of the *pathology* of ophthalmoplegia interna, the lesion is presumably nuclear. In syphilitic cases, it is most probably either a gumma or a degenerative process, due to endarteritic changes in the region of the third nerve nucleus.

The most common cause of ophthalmoplegia interna is syphilis of the central nervous system. Among the less frequent causes may be

mentioned post-diphtheritic paralysis, trauma, and overstimulation with mydriatics, as atropin.

When a syphilitic infection occurs, the local spirochete inoculation is soon followed by a general infection.

Of the tissues which are equally accessible in a general infection, the most vulnerable will be the first attacked. At the same time this tissue heals, it develops a resistance against the infecting agent. In other words, it becomes less vulnerable, a property which the unaffected tissues do not as yet possess. This is illustrated by the definite line of invasion which we constantly find in a general syphilitic infection. It begins with the local site of inoculation, followed by invasion of the glands, mucous membranes and deeper tissues, each usually separated by periods of apparent perfect quiescence. Only exceptionally is the central nervous system invaded, and then this is usually the last tissue to be attacked.

Wile and Stokes demonstrated biologic changes in the cerebrospinal fluid in 63 per cent. of their cases presenting secondary syphilis. They concluded, however, that not more than 5 per cent. of these cases later gave destructive manifestations of central nervous syphilis.

Grossman regards ophthalmoplegia interna as a rare condition; it may be familial. It may be the only objective evidence of congenital syphilis of the central nervous system. All offspring should be carefully examined for latent syphilis when the parents are known to be infected. When evidence of latent syphilis is found, treatment should be instituted; it must be continued until all clinical and biologic evidence of the disease disappears. In the writer's cases, the condition was due to a strain of spirochete which probably possess a selective property for nerve tissue. See, also, **Iridoplegia,** p. 6610, Vol. IX; as well as **Cycloplegia,** p. 3641, Vol. V of this *Encyclopedia;* also several minor captions under **Neurology of the eye.**

Ophthalmoplegia intima (Hutchinson). Paralysis of the internal muscles, or combined iridoplegia and cycloplegia. See **Ophthalmoplegia interna.**

Ophthalmoplegia mixta. That form in which both the internal and external oculomuscular groups are affected.

Ophthalmoplegia, Parinaud's. Paralysis (of peripheral origin) of the external rectus muscle of one eye associated with spasm of the internal rectus of the other.

Ophthalmoplegia, Recurrent. A name for ophthalmic migraine. See p. 7697, Vol. X of this *Encyclopedia;* also under *Migraine* in **Neurology of the eye.**

Ophthalmoplegia, Sauvineau's. Paralysis of the internal rectus muscle

of one side and spasm of the external rectus of the opposite side. This affection is the reverse of Parinaud's ophthalmoplegia.

Ophthalmoplegia, Total. A form of the disease that affects both the extrinsic and the intrinsic muscular apparatus of the eye.

Ophthalmoplegia, Wernicke's pseudo-. See under **Neurology of the eye.**

Ophthalmoprosepsis. A little-used term, to define the accommodating power of the eye for both near and distant vision.

Ophthalmoprostatometer. EXOPHTHALMOMETER. The name originally given by Cohn to his exophthalmometer (q. v.).

Ophthalmoptosis. A synonym of exophthalmos.

Ophthalmo-reaction. Local reaction of the conjunctiva following instillation into the eye of toxins of typhoid fever and tuberculosis. The reaction is much more severe in persons affected with these diseases than in the healthy or those affected with some other disease. Called, also, **Calmette's ophthalmoreaction,** p. 1361, Vol. II of this *Encyclopedia.*

Ophthalmorrhagia. Hemorrhage from the eye.

Ophthalmorrhea. A watery or sanguineous discharge from the eye.

Ophthalmorrhea externa. A discharge from the eyelids.

Ophthalmorrhea interna. A discharge from the eyeball.

Ophthalmorrhexis. Rupture of the eyeball.

Ophthalmo-sanitary legislation in various lands. See **Legal relations of ophthalmology,** in the last third of the section.

Ophthalmoscope. The chief facts concerning the discovery of the ophthalmoscope, and information regarding the several modifications of the original device to the present time, have already been to some extent discussed under **Helmholtz,** p. 5753, Vol. VIII; **Examination of the eye,** p. 4748, Vol. VI; **Coccius's ophthalmoscope,** p. 2310, Vol. IV.; **Demonstration ophthalmoscope,** p. 3814, Vol. V; **Arlt's orthoscope,** p. 591, Vol. I; **Electric ophthalmoscope,** p. 4230, Vol. VI; **Baum's electric ophthalmoscope,** p. 914, Vol. II; **Binocular ophthalmoscope,** p. 969, Vol. II; **Hydrophthalmoscope,** p. 6085, Vol. VIII, of this *Encyclopedia;* also under such captions as **Microophthalmoscope; Orthoscope; Ophthalmoscopy, Medical; Ophthalmoscopy; Ophthalmology, History of,** etc. The matter furnished in these sections is supplemented here by the following study.

The literature of the subject—especially of the earlier instruments—is very voluminous. For all practical purposes, however, the latter subject is fully covered by the joint, illustrated article of Harry Friedenwald and Casey Wood in the *Journal of the Am. Med Assoc.,* March 1, 1902. The reader is also referred to the chapter by Gould in Vol. 2 of Norris and Oliver's *System of Diseases of the Eye.*

History of the ophthalmoscope. [The Editor is much indebted to Thos. H. Shastid for this subsection.]

Even the ancients, as a matter of course, had noticed that the eyes of certain animals are brilliant in the dark. Thus Pliny (Book XI, Chap. 55): "The eyes of animals that see at night in the dark, cats for example, are shining and radiant, so much so that we cannot bear to gaze upon them; those of the she-goat, too, and the wolf are resplendent, and emit a light like fire." Pliny did not, however, attempt to explain the phenomenon.

In 1704, Jean Méry, of Paris, performed his famous experiment with a cat. Having immersed the animal in water, he first observed that the pupil dilated (as a result of suspended respiration) and then he beheld in all its glory the fundus of the animal's eye—the entrance of the optic nerve and all the colors and vessels of the choroid. Méry understood quite well enough that something more than mere pupillary dilatation was necessary to account for the possibility of observing the fundus of the eye when the eye was under water. His explanation, however, of the "something more" was wholly erroneous. He believed, that is to say, that the view of the fundus was rendered possible by the water's filling up a multitude of tiny "unevennesses" on the anterior surface of the cornea. Five years later, de la Hire stepped forward with the correct explanation. According to him, the water obviated the refraction of light by the cornea, so that all rays leaving a given point upon the fundus emerged from the eye not as parallel, but as divergent, rays. De la Hire also observed, incidentally, that the disturbing light-reflexes proceeding from a cornea *in aero* are done away with by the water.

In 1796 Fermin observed a certain luminosity in the pupils of an Ethiopian albino. In 1816 Scarpa remarked upon a similar phenomenon in a certain disease of the fundus, and, one year later, Beer described the same condition fully, inventing therefor the expression "amaurotic cat's eye"—a term which is still in use. In 1836 Hasenstein first produced a factitious luminosity by compressing the eyeball backward—making the eye, in fact, artificially hypermetropic. In 1847 Babbage, an English mathematician, exhibited to Wharton Jones, the distinguished London oculist, the model of an instrument invented by him for the purpose of examining the interior of the eye. It consisted of a small plane glass mirror, from which a portion of the silvering had been removed. This device, however, was first made known to the world in 1854, by Wharton Jones (*Brit. and For. Medico-Chir. Review,* Oct., 1854). The services of Brücke (in 1845, published

in 1847) and of Cumming (in 1846) are adverted to herein by Helmholtz.

The best description of the Helmholtz ophthalmoscope is furnished by the inventor himself. It is to be found in his immortal *Beschreibung eines Augenspiegels,* Berlin, 1851, a complete translation of which—the first in any language—here follows: The present treatise contains the description of an optical instrument, by which it is possible in the living to see and recognize exactly the retina itself and the images of luminous objects which are cast upon it. The instrument has, for this purpose, two different problems to solve. First, everything which we can see of the background of the uninjured eye appears to us absolutely dark. The cause of this lies, as I will show, in the light-refracting media of the eye, which, under ordinary circumstances, hinder us from seeing illuminated parts of the retina behind the pupil. Therefore, the first question is to discover a means of illumination whereby exactly that portion of the retina on which we gaze through the pupil may be adequately lighted. Secondly, we view the background of the eye only through the light-refracting media. These, however, cast images of the retinal objects, which, in general, do not lie for the observer within the limits of plain vision. We need, therefore, together with a proper procedure for illumination, also further optical expedients which will render possible for the observing eye a correct accommodation for the objects which it should see.

I. Illumination.

In order to be able to find the essential conditions for the method of illumination, we must first of all make clear to ourselves why, as a rule, the ground of the eye behind the pupil appears to us to be of so deep a black.

The cause of this is not the condition of the pigment of the chorioidea; for, if the pigment layer absorbed the light which falls upon it even more completely than any other known black substance, still, there lie before the chorioidea parts which can reflect a quantity of light sufficient to render them visible. That is true, first of all, of the substance of the retina, which, to be sure, in the recent condition, is very transparent, and marks itself off but little against the dark pigmentary background; to a much higher degree, however, it is true of the blood-vessels of this membrane, whose tiny stems carry blood enough to exhibit a strongly red hue. Finally, there appears, even in the fundus of the eye, a shining white spot, namely, the place of entrance of the optic nerve, on which no pigment at all lies, and which, therefore,

reflects all the light that falls upon it. And yet we observe, under ordinary circumstances, behind the pupil of the living eye, not the slightest trace of the red color of the blood, nor of the white color of the optic nerve.

It can be shown much better by a simple experiment, that not the color of the background, but only the refraction of the light in the ocular media, is the cause of the deep blackening of the pupil. Let one take any kind of small camera obscura well blackened within, and let him bring to the place where the picture is produced an opaque white card, for example one from thick white drawing-paper. Among other kinds of camera may be employed the ocular tubes of most microscopes, after the ocular glass has been removed therefrom, and the collective glass has been inserted. These tubes are, as a rule, precisely as long as the focal distance of the collective glass. If one sets them with the end which contains the ocular upward upon the white card, then they form a camera obscura of the kind we need. There are thrown, in this case, very bright images of the surrounding illuminated objects, on the white card, and still the interior of the instrument, when one looks into the lens in any desired direction, appears absolutely black. We have here a *fac simile* of the eye, where cornea and crystalline lens are substituted by the objective lens of the camera, and the retina by a clear white paper surface, but there occurs apparently the same complete darkness of the internal space as in the eye, as long as the paper surface lies precisely at the spot where the tiny images of external objects are produced. If one takes away the convex glass, or if one materially alters its distance from the paper surface, there appears to the beholder at once the clear white surface of the paper.

How, now, can the refraction of the light produce the phenomenon described? Let us consider the course which the rays of light must take, according to the physical laws of the refraction of light in the eye.

Let light fall from a luminous point upon a fittingly adapted eye, concerning which we assume that it is formed with absolute accuracy, that is, that all the incident rays from the point in question concentre upon a single point of the retina. Of the light which, by the ocular media, is caused to converge upon this membrane, the greater part is absorbed by the black pigment, while the smaller is reflected partly by the nerve elements and blood-vessels, partly by the layer of rod-shaped corpuscles. That which is thrown back by the latter structures, passes, as E. Brücke has shown, back out through the pupil, without becoming scattered to any other portion of the wall of the eye. In this way is avoided the spreading of perceptible quantities of dispersed

light within the eye. The reflected rays, which, from the point of convergence on the retina, pass back out divergently to the refracting surfaces of the eye, follow then precisely the same path, in a reverse direction, by which the incident rays of the luminous point converged from the refracting surfaces of the eye until they reached the retina. From this it follows that the returning rays, even after they have passed clear through the refractive media and out of the eye, must coincide completely with the incident rays, must therefore finally all betake themselves to the original luminous point.

For, when two rays, which pass through several simply refracting media in a reverse direction, coincide in one of the same [media] they must do the same in all [the media]. On the limiting surfaces of the medium, that is to say, within which they coincide, the angle of incidence of the outcoming rays is identical with the angle of refraction of those which are entering. As, now, according to the laws of refraction, the proportion of the sine between the angle of incidence and the angle of refraction of the former, is precisely as large as that between the angle of refraction and the angle of incidence of the latter, so must also, on the other side of the refracting surface, the angle of refraction of the outcoming and the angle of incidence of the ingoing, rays, be equal. As, at the same time, all these rays lie in one plane, the plane of refraction, it follows that they also fall into one another [coincide] in the second medium. In like manner it follows further for the third, fourth medium, and so on.

Let us apply that to the case where any given system of refracting surfaces produces an exact image of the luminous point *a* at the point *b*, that is, where all the rays which proceed from *a* unite again in *b*, then follows the well known fact that in this case, always, *a* will be the image of *b*, if the latter sends out rays. Exactly upon the same paths, that is to say, on which rays from *a* proceed to *b*, they may also return from *b* to *a*. If now *a* is a luminous point outside the eye, and *b* its image, a point on the retina, then the ocular media will concentrate the returning light precisely at *a* into an image of *b*. The image of the illuminated retinal point will coincide exactly with the original point of luminosity. The same is still valid, also, when we have to do not with a luminous point, but with a luminous surface or a body, as soon as the eye is adapted for its outlines. All the incident light which is thrown back can always only return to its place of origin, and never can proceed in any other direction.

From this it follows that, without special expedients, we can see nothing of the illuminated portion of the retina, because we cannot bring our eye into the direction of the returning light without at the

same time cutting off the incident light absolutely. To our pupil no light from the depths of the other's eye can return which has not proceeded from it [i. e., our pupil]. And as, in general, none at all has proceeded from our pupil, it sees in the darkness of the other's eye merely the reflection of its own blackness; only those portions of the retina become visible to it on which its own dark image is copied.

We have until now assumed that the observed eye furnishes absolutely accurate images. When that is not the case, the propositions heretofore laid down do not hold strictly true, the returning light will indeed proceed to the illuminating body, but it will also in part pass by that, and an observer who approximates himself to the line of direction of the incident light, will be able to perceive a part of the light which is coming out. On this fact are based the methods of Cumming (*Medic. Chirurg. Transactions*, Vol. 29, p. 284) and Brücke (*J. Müllers Archiv.* 1847, p. 225) for observing the illumination of human eyes. From what has been said it is manifest that, in this way, the illumination must be the greater, the less exactly the rays of a luminous point are concentrated on a point of the retina, therefore especially in faulty adaptation. Besides, I have convinced myself that one may observe a weak illumination, according to the method of E. Brücke, even in eyes with good acuity and under perfect adaptation for the luminous body, from which is to be concluded that, under all circumstances, a small quantity of incident light is scattered laterally. The cause thereof may be inexactness of the eye, incomplete transparency of its refracting parts, or diffraction at the border of the pupil.

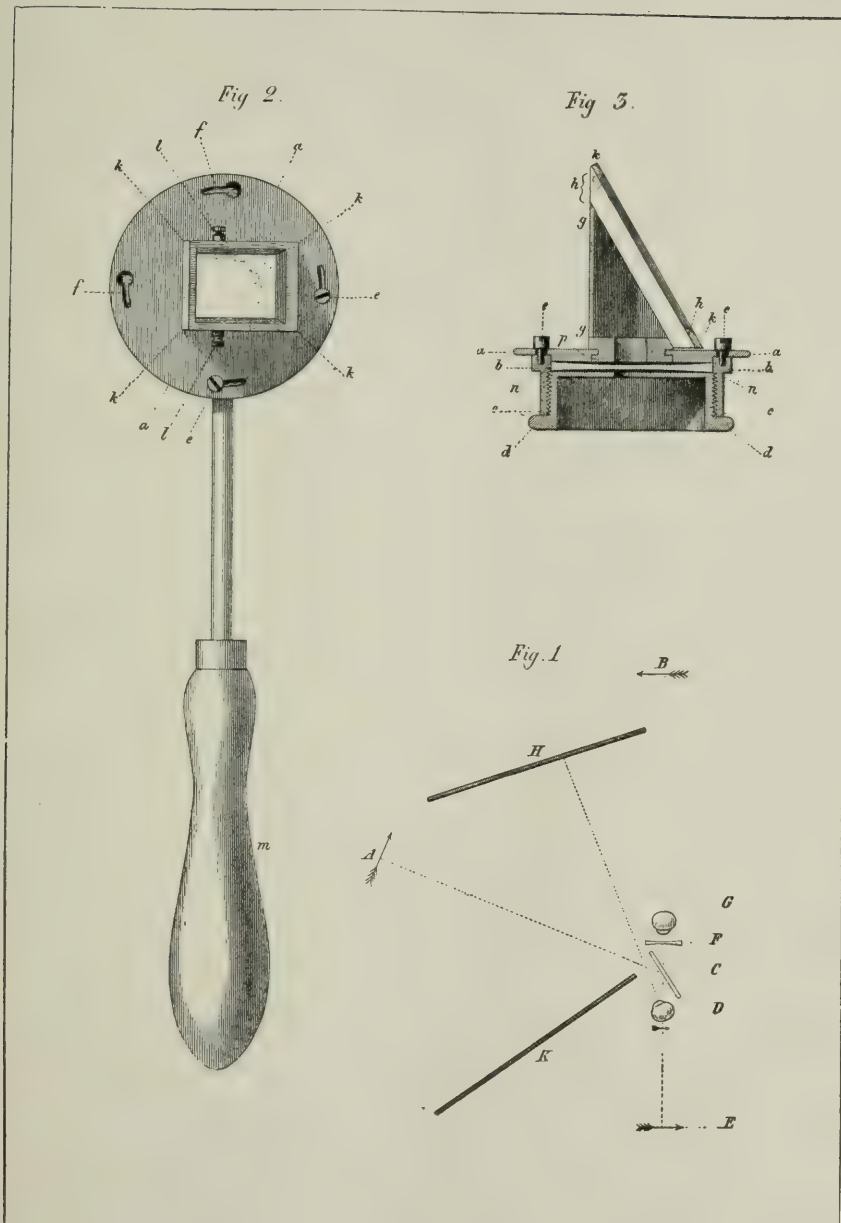
In any case, the observer perceives, in this experiment, only a small part of the returning light, and indeed precisely that which is irregularly refracted and which cannot be used for the production of a regular image. Some other method is necessary for the attainment of our object, a method which makes it possible to look into the eye not merely somewhat, but exactly, in the direction of the incident light. The expedient for this has already been found in an accidental observation by E. Brücke. v. Erlach, who wore spectacles, saw, indeed, the eyes of an acquaintance shine, when the acquaintance saw reflected in the lenses of the spectacles a light which there was in the room. In this way, therefore, uncovered lenses were employed as illuminating mirrors, and through these very objects the observer looked toward the observed eye. Precisely the same expedient we shall employ for our purpose, replacing, however, the spectacle lenses to advantage by well ground plane glasses.

In a darkened room, where only a single source of light, a well burning lamp or an opening in the window shutter for the sunlight, is

present, let one set a small, plane glass plate in such a way that the observed eye may perceive therein the mirrored image of the light, without, however, its necessarily gazing at this mirrored image directly. From out the anterior surface of the lens there falls, by this arrangement, light into the observed eye, and through the same glass at the same time the observer can view the eye, without, while so doing, being in the least aware of any light which is being reflected from its anterior surface. One sees that, in this way, it becomes possible to look into the subject's eye in precisely the same direction as that in which the light falls upon it. Under these circumstances the eye of the observer in fact receives light from out the depths of the other eye, and sees its pupil apparently grow luminous.

In Fig. 1, let A be the flame, C the glass plate, D the observed, G the observing eye. The light from A which falls upon the mirroring plate, is by that partly reflected, and the reflected part continues according to the laws of catoptrics, as if it proceeded from the reflected image of the flame at B. For the observed eye this mirrored image represents the place of the luminous object, and upon its retina is thrown an inverted and minified image. Moreover, the axis of this eye can be turned in any direction, say toward the object H. According to the already developed rules, the refractive media of D cast the image of its retina and of its retinal images again at B. For B is the apparently present object for the eye D, and the rays returning from D must proceed again to their place of origin. On the way from D to B this light encounters once more the reflecting plate, a part is reflected and returns to the real flame A, another portion passes through the glass and strikes the eye of the observer G.

By this arrangement the pupil of the eye D appears to shine with a red light, and indeed as a rule more strongly than I have seen it do by Brücke's method. According to that method, there contributes to the illumination only the little light which, in the eye, is not completely and regularly refracted; according to the method just described, on the contrary, the entire light, with the exception of the part (to be sure not an inconsiderable part) which is lost by the passage through the reflecting glass. Moreover, the illumination is of very different strengths, when different portions of the retina receive the image of the flame. When the eye D turns in different directions, the clear retinal image must always remain in the prolongation of the line B D, and will therefore fall successively on various portions of the background. If it falls on the place of entrance of the optic nerve, then the most of the light is reflected, the pupil lights up with a strong yellowish white, almost as if the flame stood behind it. The



Helmholtz Ophthalmoscope.

Photographic Reproduction (Actual Size) of the Original Illustration in Helmholtz's *Beschreibung eines Augenspiegels.* (Shastid.)

retina proper, on the other hand, reflects less, and indeed red light. In general, the image of the flame upon it appears the brighter, the nearer; the darker, the farther, it lies from the place of entrance of the optic nerve. On the contrary, the place of direct vision, the yellow spot (which is struck when the observed eye D gazes directly at the mirrored image of the flame at B) reflects, by way of exception, very much less light than the parts which are nearest to it, and is therefore the most unfavorable spot for this experiment.

In order to fulfill the condition that the observer gaze into the eye exactly in the direction of the incident light, the glass plate may be directed either by the observed or by the observer. If the former is to do it, let him turn the plate first of all so that he sees therein the mirrored image of the light, then again so that this image appears to him exactly in the same direction as the observing eye, that, in other words, the latter and the mirrored flame cover each other. In this way the required condition is fulfilled. At the same time occurs this inconvenience, that the observed eye must look directly at the flame, the retinal image therefore falling precisely on the spot whence the light is the least reflected. If, however, the observed eye, after it has found the correct position, turns a little sidewise, in order to let the light shine more brightly, then the pupil becomes displaced and the correct position is disturbed. Still, one can then assist the matter by gentle turning of the mirror now this way and now that.

It is better, however, to perform the experiment in another way, whereby the observer holds the glass himself. One must, by this method, shade the face that is being observed, and make the reflecting plate so small that it is barely large enough to see through. The light reflected from it then produces on the shaded face of the observed a small, bright spot, which has about the form of the reflecting glass. This point should be so managed by the observer that its centre falls upon the observed eye, while he himself looks through the glass. In this way the glass may easily be placed correctly, and the observed eye may, without the slightest difficulty, be turned toward all sides in order to cause the image of the flame to fall on different parts of the retina.

Every person can, furthermore, in similar fashion, by the aid of a bit of plane glass, see one of his own eyes grow luminous. He should step before a mirror, set up a lamp at one side, hold the glass before his right eye in such a way that he sees the flame reflected in the plate, and turn the glass so that the image of the flame coincides with the mirrored image of his left eye; then the left eye sees the mirrored

image of his right pupil grow luminous, but of course only weakly so, because the retinal image falls on the outer side of the eye at a considerable distance from the optic nerve.

Moreover, the same simple expedient permits itself to be employed with advantage for illumination, in every instance when one wishes to look into a dark cavity with a narrow opening, for example, the auditory meatus, the nose, and so on. In order to view the drum membrane, one should seat the subject of the experiment with his back toward the window, preferably in sunshine, draw the auricle a little downward, and cast the reflected sunlight into the auditory meatus, while one gazes through the glass. In this way one may very easily and conveniently illuminate the tympanic membrane as strongly as he wishes, and so observe it.

In order to see the pupil become luminous, any simple plate of glass suffices for the mirror; one does not need in that case to pay particular attention to the intensity of the light. Should it be desired, however, by means of this light to recognize distinctly the structure of the retina and the character of the image of the flame, then one must endeavor to make the illumination as strong as possible. That can be done in two ways, namely, by a proper choice of the angle under which the incident light is reflected from the mirroring plane, and by an increase in the number of the reflecting plates. I will now unfold the principles which have guided me in this connection during the construction of my instrument, and which would also serve as a basis should oculists think it necessary to produce modifications of the instrument for practical purposes. For those of my readers to whom the physical conceptions involved are not familiar, I remark furthermore that this exposition is not necessary for an understanding of the sections to follow.

From every limiting surface of a glass plate, the more light is reflected the larger the angle of incidence, that is, the angle between the ray and a line which stands vertical to the plate. Since, in the case of reflection from the upper surfaces of transparent bodies, the light waves of different undulatory directions conduct themselves differently, we must think of the incident light as divided into two equal parts, of which the one is polarized parallelly to the reflecting surface, the other vertically thereto. The light-intensity of all the incident light we will call J, therefore that of each of the two divisions mentioned $\frac{1}{2}$ J, the angle of incidence (angle between the incident ray and the incident-perpendicular) a, the angle of refraction (between the refracted ray and the incident-perpendicular) a_1, the index of

refraction n. If a is given, we find first of all a_1 by means of the equation

$$\sin.\ a = n\ \sin.\ a_1.$$

The intensity P of the light reflected from a limiting surface between air and glass and polarized vertically to the plane of incidence, is, according to the formula of Fresnel

$$P = \frac{J}{2} \cdot \frac{\text{tang}^2\ (a - a_1)}{\text{tang}^2\ (a + a_1)}$$

Likewise the intensity Q of the reflected light which is polarized parallelly to the plane of incidence

$$Q = \frac{J}{2} \cdot \frac{\sin^2\ (a - a_1)}{\sin^2\ (a + a_1)}$$

When several reflecting plates lie parallel, one behind another, and the illuminating surface is sufficiently large for its mirrored images, which are produced by the individual reflecting surfaces, to superimpose themselves, in greatest part, for the observed eye, then the individual images combine into one image of greater brightness. By computation of the quantities of light reflected to and fro between the different surfaces, one is able to determine for every system of parallel surfaces, how much light is, on the whole, reflected. For an indefinite number n of the reflecting surfaces one finds the sum Π of the light polarized vertically upon the plane of incidence

$$\Pi = \frac{n\,P}{J + 2\,(n - 1)\,P}\,J$$

and the sum Σ of that which is polarized parallelly to the plane of incidence

$$\Sigma = \frac{n\,Q}{J + 2\,(n - 1)\,Q}\,J$$

As I find these formulæ in no writing on physics I give their derivation briefly at the end of this essay.

The sum Π + Σ gives us the entire quantity of light which is thrown back from the system of reflecting surfaces and which proceeds to the observed eye. We will set it down as equal to H, so that

$$H = \Pi + \Sigma$$

When the width of the pupil remains unchanged, the brightness of the retinal image is proportional to this quantity of light. The quantity of light returning from the eye we may therefore set down as equal to m H, where m designates a coefficient whose value is constant for different light-intensities, though dependent on the nature of the place on the retina from which the light proceeds. The returning light divides at the reflecting surfaces once more into a reflected and a transmitted portion, only the latter arriving in the observer's eye. The light which is reflected at the retina possesses, as is generally the case with diffuse reflected light, no longer any polarization, conducting itself in this respect, therefore, like the light from the light-source as it strikes upon the mirror. Inasmuch as, in addition, it falls upon the plates under the same angle, proportionately as much of it is reflected and transmitted as of the former [the light from the light-source]. If we designate the transmitted part by X, then we have the proportion

$$X : m\,H = (J - H) : J.$$

From this may be computed the quantity of light X, which passes into the eye of the observer. For $H = 0$ and $H = J$; that is, when no light or all the light is reflected, X will $= 0$. Between these extreme values of H exists a maximum of the value of X, which can be computed according to the known rules of the differential calculus. The maximum occurs when

$$H = \tfrac{1}{2}\,J.$$

Then will

$$X = \tfrac{1}{4}\,m\,J.$$

By this condition is also determined for a given number of reflecting plates the angle under which the reflection must occur in order to give to the observer the brightest image. Unfortunately, the equation which expresses the dependence of the value H on the angle of incidence a, cannot be solved after a; we can therefore find the proper values of a only approximately by means of computational trials. Besides, it is of no use to drive the exactness of this computation very far, first, because the brightness for the observer is not materially altered, even when the position of the glasses is not that requisite for the maximum, and, secondly, because the alterations in the width of the pupil produced by different intensities of the incident light cannot be taken into account.

As the pupil of the observed eye becomes smaller under stronger incident light, the brightness of the retinal image will not increase entirely in the same proportion, when the values of H increase, as

they should do according to the developed formulæ. It is therefore more advantageous to re-establish in the instrument the values of H as somewhat smaller than would be requisite for the maximum of H in the foregoing computation. One reaches, for example, the value, which slightly deviates from the foregoing maximum,

$$X = 1/5 \text{ m J}$$

when the light is reflected from one glass plate at an angle of about 70°, from three at an angle of 60°, of four at 55°, and these positions are therefore approximately the most advantageous.

The necessary brightness, therefore, can even be reached with a single glass plate for a mirror. The use of several plates at a smaller incidence-angle has, however, essential advantages if one would attain to distinct images of the retina. First of all, glass plates, even when they have well ground parallel surfaces, are not always internally of so homogeneous a structure as still to yield, by an oblique view, good, distinct images. Then, it is more difficult, by a very oblique view, to give to a reflecting plate the correct position toward the observed eye, and to hold the plate therein. Also, the observer, by the lateral parts of his head, cuts off more easily the rays of light which should fall upon the mirror; especially may this be avoided with difficulty when the angles of incidence are more than 70°. Finally, it remains to be especially considered that a small quantity of the light which falls into the observed eye is in fact reflected from its cornea and appears to the observer as a washed-out light spot in the visual field. This falls over the centre of the pupil, when the observed eye turns straight toward the mirror, therefore when it looks directly at the mirrored image of the flame; it falls more to one side when the observed eye gazes in any other direction, disturbing, however, the observation of the retina always more or less. It is therefore an essential advantage if one can weaken the corneal reflex for the observer to a considerable degree. Now, in fact, that image appears much weaker when 4 plates reflect at 56°, than when 3 reflect at 60° or one at 70°, while the retinal image, as already mentioned, holds to just about the same illumination. That is to say: the apparent brightness of the corneal reflex is not proportional to that of the retinal image, because the light which falls into the observed eye, and which is partly or wholly polarized by reflection, is depolarized by the diffuse reflection at the retina—something which does not occur from the specular reflection at the cornea. If the cornea, of the quantity of light A which falls upon it, reflects the portion μA, then the quantity of light which, in our experiments, passes from the

cornea into the eye of the observer, equals, according to the same principles and the same designation as before,

$$\frac{\mu \Pi [J - 2 \Pi] + \mu \Sigma [J - 2 \Sigma]}{J}$$

Computation gives the result already stated. It is therefore from every point of view more advantageous to attain the necessary brightness by increasing the number of the plates, while they reflect the light at the polarization angle of 56°, than by increasing the angle of incidence, indeed the corneal reflex could be made to disappear entirely by increasing very much the number of the plates.

I have assumed, in the foregoing explanations, that the flame of a good oil-lamp with a double draught is employed as the light-source. When the experiment is properly conducted, the light of such a lamp is not so strongly reflected as very much to dazzle or fatigue the lateral parts of the retina of the observed eye. One can therefore easily continue the experiments as long as one likes. Only when the eye looks directly at the mirrored image of the flame, will this degree of brightness be found not long endurable. If one has at his disposal a more intense light, for example sunlight, which falls into a dark room through an opening in the window-shutter, then one can see the picture of the retina much brighter, if one, after proper weakening of the light, causes it to reflect from a mirroring-plate as vertically as possible, than when this takes place obliquely. The quantity of light which one may permit to enter into the eye is limited particularly by the sensitiveness of the latter. If, now, one has at his disposal excessively strong light, which by every kind of reflection, if it is not at the same time adequately weakened in another way, exceeds this limit, then the observer sees the retinal image, which has reached the limit of endurable intensity, at its brightest when as little as possible is lost at the second reflection. That is, however, the case when the light is thrown back from a plate almost vertically.

I have not had opportunity to institute such an investigation by means of sunlight; I do not believe, however, that, by that method, any considerable advantages are to be secured, because, in the case of vertical reflection, the apparent brightness of the disturbing corneal reflexes increases at a much higher rate than that of the retinal image.

There was expressed to me a number of times the supposition (at first blush a very plausible one) that, by a convex lens which should concentrate toward the observed eye all the light which falls upon it,

the quantity of light falling into the eye and therefore also the brightness of the retinal image, could be considerably increased. I will therefore here direct attention to the fact that, in this way, not the brightness but only the size of the retinal image is increased. When we bring the eye to the point of union of the light-rays, which have passed through a lens, then the entire surface of the lens appears to us luminous with that light-intensity which belongs to the luminous point. Instead of the smaller retinal image of the luminous point, there forms itself for us therefore a larger one with the same intensity, that of the lens-surface. Moreover, by no complicated arrangement of lenses can the brightness be increased. In order to perceive this, we need only to remind ourselves of this fact from the theory of telescopes, that through no telescope or similar arrangement of lenses can an object of appreciable diameter appear brighter than with the naked eye. As, now, the inhabitant of the seeing eye subjectively perceives the surface no brighter through the lenses, so can, objectively, the image in his eye by the use of no sort of lenses be brighter than without them. For to an objectively brighter retinal image there must always correspond a stronger subjective light-perception.

2. Production of a Distinct Image of the Retina.

We now come to investigate how, by means of the light which, returning from the retina of the observed eye, falls into the eye of the observer, we may be able to receive distinct images of the retina itself, and of the picture of the light-source cast upon it. For this purpose let us take again our Fig. 1. According to the explanations just made, the ocular media will so refract the rays returning from points of the retina of the eye D, that they come together outside the eye and indeed in the corresponding points of the image B. The image which the ocular media cast of the retina and of the retinal image of the flame, coincides therefore in size and position with the first reflected image of the flame. An observer who (reckoning outward from the mirror) stands on the other side of B and at the distance of distinct vision from B, would therefore in fact be able to see that image of retinal objects distinctly. His visual field, however, limited by the pupil of the observed eye, would, at the comparatively considerable distance of the two eyes from one another, be so small that it would be impossible to combine the viewed details into a complete picture.

The regard which we must pay to the enlargement of the visual

field, makes it much more necessary to approximate the two eyes as closely to each other as possible. Then, however, the image B falls in general behind the back of the observer, and can not be plainly seen by him. If, for example, in Fig. 1, the observing eye is at G, then it receives the light rays which proceed out of the eye D and which come together at the points of B. Now a normal eye can indeed unite upon its retina parallel rays, as these move from infinity, and divergent, as these come from nearer points, but not convergent rays. The simplest way to assist in this matter, and to make the convergent bundles of rays divergent, is a concave lens, which is inserted between the mirror and the eye of the beholder, as in Fig. 1 at F.

According to the known laws of refraction in concave lenses, the convergent rays which strike upon F will, after their exit from the lens, either be less convergent (when, that is to say; the focal distance is greater than FB) or they become parallel (when the focal distance equals FB) or, finally, divergent, as if they came from points of an image E behind the observed eye (when the focal distance is smaller than BF). In the latter case the concave lens acts precisely as it does in opera glasses, where it likewise converts the inverted imperfect image, which the objective lens should cast at its focus, and which lies on the side of the observer, into one which stands upright and which appears to the observer to be on the other side of the glasses. In our case, likewise, the ocular media form the objective glass of a microscope, which is constructed on the principle of a Gallileonian telescope, while the concave lens represents the ocular.

If the accommodation distance of the two eyes DB and GE are given, and in addition the mutual distances of the eyes and the concave lens are settled according to the principles above set forth, that is, made as small as the mirror permits, then is the focal distance which is to be given to the concave lens to be determined according to the known laws of refraction in lenses. This is found to equal

$$\frac{EF \quad BF}{EB}$$

or:

$$\frac{(EG - GF) \ (BD - DF)}{EG + BD - DG}$$

The greater are the accommodation distances EG and BD, the greater must also be the focal distance of F. The observer will,

therefore, if one of the two eyes is short-sighted, employ stronger concave lenses, but, if one eye is far-sighted, weaker ones, than for two normal eyes. When the observing and the observed eye exchange their rôles, without altering the condition of their accommodation, there will generally become necessary a glass of a different focal distance, and, indeed, as $GF < DF$, a weaker one, when the more short-sighted eye observes, than when it is observed. Still, a closer consideration of the foregoing formula shows that this difference is extremely slight in the case of not too short-sighted eyes, so that, in the case of such, the same glass can serve for mutual observation.

The magnification is determined according to the known laws of optics in this way, that the image E, viewed from the center of the lens F, must appear under the same visual angle as B, its imaginary object. Since the eye G, the lens F and the eye D stand as closely together as possible, then will B appear from F only a little larger than from D. The eye G therefore sees the retinal image of the flame magnified, and indeed just as large, or, considered exactly, a trifle larger, than the eye D sees the original flame. The parts of the retina on which the image of the flame falls, appear likewise in the image E again, magnified of course in the same proportion as that.

According to what has just been said, the proportion of this enlargement is equal to that of the retinal image to its object. Let us take as the distance of the decussation-point of the refracted rays from the retina, according to Volkmann's measurings, 4 lines, for the distance of the object from the eye the normal visual distance of 8 inches, then the magnification is found to be 24 times.

We have compared the ocular media in our experiment with the objective of a microscope, the concave glass with the ocular. Now, in place of the latter, one should be able to produce a combination of two convex lenses, which stand at a distance from one another of less than the sum of their focal distances, as is the case in the ordinary compound microscope. The first of the lenses would, like the collective glass of this instrument, unite the weakly converging light-rays which proceed from the observed eye, more promptly to an image, which, situated between the lens and its focal distance, would exhibit the flame-image upright, the retina inverted. This image could then be seen magnified by the second convex lens. I have debated the results of such a combination, according to the known laws of optical instruments, with respect to magnification, illumination, visual field, etc. As the computation showed that in this way no essential advantages were to be secured, as compared with the simple concave lenses, it will here suffice to adduce those results very

briefly. It is hereby presupposed that the first lens, so far as the mirror permits, is approximated to the observed eye, and that the observing eye lies close to the second lens.

First of all, as to the illumination, the maximum thereof is directly attained by a concave lens for the middle of the visual field. If the same thing is to occur by two convex lenses, then these must be so chosen and arranged that no other enlargement takes place than by the concave lens, that is, in such a way that the magnified retinal image of the flame appears to the observing eye under the same visual angle as the mirrored image of the flame does to the eye that is being observed.

If this enlargement is to occur, the image from the first lens must fall, as in the ordinary ocular tubes of the compound microscope, in the middle between both lenses. In the case of a weaker magnification, it is possible to cause a larger portion of the visual field to appear in the maximum of brightness; in the case of stronger, on the contrary, that can no longer occur even in the middle. As advantageous, therefore, as even a stronger magnification might be, still such a one is not practicable, because the illumination would thereby suffer too much, and a living eye would not well endure for a longer time without dazzling the incidence of still stronger light than that reflected from a good lamp. Then, too, is the fact that the living eye cannot be thoroughly fastened, as would be necessary for the fixation of individual parts of the image in the case of stronger magnification.

Next to be considered is the visual field. The part of the retina which one can survey is always the smaller the farther one removes oneself from the observed eye; the larger the nearer one comes to it. The limit of approximation is, however, set in this way: that the obliquely placed mirror-plates have to be inserted between the eye and the glass-lenses.

In order to compare by means of computation the effects of various lenses, we must therefore accept as equally great the distance of the concave glass and that of the first convex glass from the observed eye. If then at the same time the condition is observed, that the brightness in the middle of the visual field should reach its maximum, then are found definite focal distances of the convex lenses for every given distance from the eye, which make the visual field at its largest. If one choose the focal distances of both the convex lenses in accordance with these determinations, then it further appears that when the distance of the lens from the eye is smaller than the focal distance which one may give to the objective of a telescope from the aperture of the pupil without prejudicing the distinctness of the image, there-

fore in the case of achromatic lenses smaller than perhaps the tenfold pupillary diameter, the concave lens, if larger, the convex lenses can give a larger visual field.* Now, in the case of the closest possible approximation of the lenses to the observed eye, the distance between both will of course, on account of the mirror being placed in the interval between the lenses, remain in general somewhat larger than the tenfold pupillary diameter, and one would therefore be able to secure by means of two convex lenses a slight advantage for the visual field. Inasmuch, however, as the lenses, in order to yield this advantage, must have focal distances of 36 to 40 lines, it may become very difficult to receive an image of the same distinctness as by a concave lens which may have a focal distance of 8 to 10 inches. I, at least, have not been successful in this matter, by the combination of such convex lenses as stood at my disposal. Moreover, it transpired, in the experiments with such lenses, that the correct location of the instrument for the perception of the retinal image is both found and kept with much greater difficulty. With a simple concave lens it is, to wit, not necessary that the axis of the lens be directed exactly upon the observed eye, if only the mirror casts light into it. This condition, however, must be observed in the case of two convex lenses.

Consequently it appears to be more advantageous to retain the simple concave lens as ocular, while one almost everywhere else in optics replaces it to decided advantage by convex lenses. A decided advantage of the latter occurs, to be sure, even in our case, which would make their employment desirable, to wit, the advantage that, by an altered distance of the lenses from each other, one can adjust the apparatus to all visual distances of the observed and the observing eye, while, for this purpose, one must exchange the concave lens for another. If one could completely make fast the head of the observed person and the instrument, convex lenses would in consequence be more convenient; without such arrangements, however, all their other advantages are outweighed by the disadvantage of the difficult placing of the instrument. I have therefore myself always employed only a simple concave lens.

3. Description of the Ophthalmoscope.

In order to institute observations of the kind described, it is convenient to unite the mirror-plates and the concave lens by means of

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* The sentence, in the original, is hopelessly obscure; it is, therefore, also obscure in the translation. The reader should recall the fact that Helmholtz, at the time when he wrote the "*Beschreibung*," was not yet master of a literary style, and I have deemed it far the fairer way not to force into the sentence a meaning of my own.—(T. H. S.)

a suitable frame. I propose for such a combination the name *Augenspiegel,* by analogy with similar instruments. The instrument is viewed in Fig. 2 from in front, in Fig. 3 exhibited in horizontal cross-section. The reflecting plates hh are fastened, by means of the brass piece gg, to the circular plate aa, at an angle which is equal to the chosen angle of incidence of the light rays—in the figure, 56°. The brass piece gg forms with the glass plates a hollow, right-angularly triangular prism. In Fig. 3 one sees into the inner cavity thereof, and has before him one of the right-angularly triangular basal surfaces. Of the three quadrangular lateral surfaces of the prism, that which corresponds to the hypothenuse of the basal surface, is formed by the glass plates, that which corresponds to the longer cathetus stands free, that corresponding to the shorter cathetus lies on the disc aa, and carries a cylindrical process p, which, by means of a corresponding circular opening in the plate aa, so clasps through, that it holds the prism fast against the plate, but permits a turning on its axis. The glass plates are held against the prismatic brass piece by the frames kkkk, whose over-reaching lateral edges are secured to the brass piece gg by the screws ll. The disc aa rests on the cylinder bbcc without being permanently fastened to it. In the border of aa, namely, there are cut four openings of the form f, to which openings there correspond four screws ee with cylindrical heads and thin necks, inserted into the border of the cylindrical ring bb. In Fig. 2 are shown only two of these screws, in order to let the holes f be seen. The heads of the screws allow of their shoving through the broad circular portions of the openings, and if then the disc aa is turned about its center, the necks of the screws pass into the smaller, slit-shaped part of the same opening, while their heads lap over and fasten the disc to the ring bb. In that way it is possible to remove the disc very easily and quickly from the setting of the concave lens, and to exchange the lens for another. The concave lens nn lies between the plate aa and the floor of the cylindrical piece dd, which is screwed into bbcc and can be set back by screwing round, when it becomes necessary to lay two lenses one upon the other for very short-sighted eyes. The whole is fastened to the handle m. For a normal-eyed observer, the numbers 6 to 12 of the ordinary concave spectacle lenses, are sufficient for the adjustment to all adaptational conditions of the eyes to be investigated. For the viewing of other normal eyes, I generally employed Nr. 10. For very short-sighted eyes, two lenses should be superimposed.

As to the reflecting plates, those of ordinary mirror-glass are not appropriate, because their two surfaces are as a rule not sufficiently

parallel to cause the images which they cast of the lamp-flame to coincide in the way that they should. The glasses must therefore for our use be especially ground, in order to receive parallel surfaces, though this condition need not be fulfilled with such exactness as in the case of the plane-parallel glasses which one employs in the finer measuring instruments.

A good blackening of the non-reflecting surfaces is essential. Since, of the bright light which falls upon the instrument, only a proportionately small part returns from the retina of the observed eye, all the remaining remnants of the light, which might perhaps get into the eye of the observer, must be done away with. First of all, the inner surface of the ocular piece dd must be blackened, and the observer must place his eye as closely into it as possible, in order to cut off all the light which could fall from the flame upon this surface. Secondly, the outer surface of the disc aa and of the prismatic mirror-frame kkkk must be blackened, in order that blank metal surfaces, which are turned toward the observed eye, may not produce disturbing corneal reflexes. Thirdly, however, the inner surface of the mirror-frame is to be blackened with especial care. The light of the flame which falls on the reflecting plate, passes in greater part through, and strikes the plate gg. All that is not here absorbed, returns to the mirror, is reflected from this in the same direction to the observing eye, in which the weak light from the retina of the observed eye arrives, and mingles with the image of this membrane. I have found, in this matter, the general methods of procedure of mechanics for blackening brass-pieces to be inadequate, and the framework of the mirror must be tapestried internally with black velvet, which absorbs the light more completely.

When one desires to use the instrument, he sets the person to be examined in a dark room and next the corner of a table on which, at a level with the eye and sidewise from the face, stands a well-burning, double-draught lamp. It is convenient to set upon the table, at a fitting visual distance, some not too bright object, whereon one can point out to the observed eye certain points for fixation, for example a blackboard divided into squares, each of which is designated by a number, while one causes the eye to fix various points one after another. The image of the flame falls ever on different parts of the retina, which the observer, therefore, may investigate one after another in any order desired. Between the flame and the observed eye an opaque screen must be erected, in order to shade the eye, so that directly incident flame-light may not produce a very disturbing corneal reflex and a narrowing of the pupil. Still, the border of the

shadow must pass very close before the observed eye, in order that the ophthalmoscope, which must itself remain in the light, may be carried toward that eye as closely as possible. The observer seats himself before the observed, brings the ophthalmoscope, without at first looking through it, into about the right position, when its reflecting surface casts a bright light upon the face. When one has so turned the mirror that the middle of its light falls upon the eye, and the axis of the instrument is directed precisely into it, one looks through. A person then has, as a rule, at once before him the bright image of the flame, or finds it after more or less moving about. Moreover, one can also, looking through the instrument, discern, to a certain extent, the eye and the clear light which must fall upon it, even if indistinctly and as if they were faded, and also, in that manner, with the help of these [the eye and the light upon it] discover the correct position. If, though the pupil appears luminous, one cannot see the various parts of the retina distinctly, then one must insert another concave lens. An observer who has accustomed himself to alter at will the adaptation of his eye, easily discovers whether he sees more plainly by a far-sighted or a near-sighted adaptation, and whether, accordingly, he must choose more or less strongly curved lenses. Moreover, many persons make the matter difficult, especially those who are not accustomed to looking through optical instruments, and short-sighted persons who see through them with difficulty, insomuch as they involuntarily adapt the eye for great nearness, because they think of the object to be seen as being very close. In that way the eyes of the observer are greatly fatigued, and readily begin to be injected and to water. It is necessary here, as in the case of all optical instruments possessing an alterable adaptation, to adjust the eye for the distance, and then to adjust the instrument to the eye.

After a little practice it is not difficult to find the right lens and the correct position of the instrument. Also, one can easily, on his own eye, show these matters to anyone who has never yet seen them, in order first to render him familiar with the appearance of what he is going to look for. In that way it will be made much easier for him to discover independently the very same things in the eyes of others. Let the instructor, for this purpose, first of all discover the particular lens through which he can see the student's retina plainly, and then let him place this in the ophthalmoscope; then through the same glass the student can see distinctly into the eye of the teacher, if neither of the two is very short-sighted. In the latter case (as explained already) the more short-sighted person needs a somewhat weaker glass when he observes than when he is observed. Let the instructor, then,

bring one of his own eyes into the position which has been described as that for the eye to be observed, and let him so hold the ophthalmoscope before him that he may be able, at the same time, to look through its central openings and glimpse the mirrored image of the flame in the mirror, hand over to the student the instrument in this position, and let him look through it. The student will then see in the eye the image of the flame. In order to teach him to recognize the appearance of the parts of the retina, let the teacher throw the image of the flame on the place of entrance of the optic nerve, because in that place the largest and most recognizable vascular trunks exhibit themselves. Let him, for this purpose, turn the eye gradually more and more to the inner side of the mirrored image of the flame, until this suddenly becomes smaller to him, or disappears. That happens, as is known, when the image falls upon the place of entrance of the optic nerve. Besides, most persons more easily succeed in seeing and recognizing the image of the flame than the tiny parts of the retina in the bright ground thereof.

4. Viewing the Retina and the Image of the Flame.

Should one desire to investigate the retina completely, then it is convenient, as already mentioned, to set up a blackboard covered with numbers as a visual point for the eye to be investigated. As soon as this eye fixes one of the numbers, looking past the mirror a little to the inward side thereof, the observer will almost always recognize in the visual field one or two of the larger vessels. He causes the eye to turn to one of the near-lying figures, and notices whether he is brought nearer to the origin or to the branching of the vessels. While, in this way, he traces the vessels in the direction of their larger trunks, he comes at length to the place of entrance of the optic nerve. This distinguishes itself from the rest of the eye-ground by its white color, for it is not covered with pigment and a fine vascular network, but here the white cross-section of the nerve lies wholly free, at the very most shot through by tiny, isolated vessels. Mostly to the inner side, near by, the arteries and veins of the retina press forward from the depths. At times one sees a portion of the vessel still hiding in the substance of the nerve, and understands that, in the living, this substance is decidedly transparent. One distinguishes the two kinds of vessels from each other by the brighter color of the blood and the double contours of the walls in the arteries and in their first ramifications. I have not been able to recognize pulsations with certainty. The first main branches of the vessels border the optic nerve at its

inner side, in order to spread out later, above and below, across the retinal field. The appearance of the sharply pencilled red vessels on the clear white ground is of surprising elegance. Somewhat farther to the inner side, close by the nerve, I have always remarked a small, sickle-shaped stripe of shadow, which appears to take its origin from a fold of the retina.

In the other parts, the ground of the eye looks reddish, and indeed first of all round about the optic nerve of a somewhat clear, light-red, the darker, on the contrary, the farther you pass from that place. One sees here larger and smaller branching blood-red vessels, which stand out plainly from the back-ground. The ground itself appears to be not entirely homogeneous, but indistinctly reddish. This would seem to arise from the fact that the close capillary net is too fine, too weakly illuminated and too transparent to be distinguished plainly from the underlying weakly, light-gray substance of the retina. That the ground looks brighter in the vicinity of the optic nerve is no doubt owing to the fact that the retina here, on account of the superimposed fibres of the optic nerve, is thicker, while, toward its periphery, it becomes continually thinner. Moreover, the place of direct vision (the yellow spot) is essentially distinguished in appearance from the parts which lie immediately about it. In order to get this point before oneself, one causes the eye which is being observed to look directly at the mirrored image of the flame. The retina then appears much darker, grayish-yellow without intermixture of red; and one sees no traces of capillary vessels. Then, too, one is greatly annoyed while gazing on the yellow spot, by the tiny image from the cornea, which obtrudes itself precisely in the center of the visual field, while, during the observation of the lateral portions of the retina, it lies to one side.

After deciding what, in the healthy eye, can be made out concerning the nature of the retina, I have no doubt that one will be able to recognize all such disease conditions as permit of recognition by the sense of sight in other transparent parts—for example, the cornea. Increased repletion of the vessels and vascular varicosities must prove easy to make out. Exudates into the substance of the retina, or between that structure and the pigment membrane, must yield themselves to observation, very much as affections of the cornea do, by their brightness against a dark ground. If they lie in part before the retina, they will then enclose its vessels in a veil. I here recall that, according to Brücke, the recent retina is just about as transparent as the other ocular media, and that, apart from its vessels, it is only visible in our experiments because it is strongly illuminated

on the deep-black ground of the pigment membrane. Fibrinous exudates, which are nearly always less transparent than the ocular media, must also for that reason, when they lie in the fundus of the eye, considerably strengthen the reflex. Then too I believe that opacities of the vitreous body will be much more easily and certainly recognizable, partly by the illumination of a reflecting glass-plate, partly by the ophthalmoscope. One will even be able to determine with ease, from the indistinctness of the image of the flame and of the retinal vessels, the degree of the opacity. If, in the case of such an opacity, scintillating particles have detached themselves, then too a person will be able to take note of these. In brief, I believe that I may hold the expectation not to be exaggerated, that all the alterations of the vitreous body and of the retina which, until now, have been found in cadavers, will also permit of recognition in the living eye—a possibility which appears to promise the most remarkable advances for the hitherto undeveloped pathology of this structure.*

Finally, it is of interest, for certain physiological purposes, to investigate the accuracy with which the eye forms images. It is best to employ for this purpose a thread, which one draws along horizontally before the flame. Its image remains single, while vertical threads are manifolded by the manifold reflections.

First of all one gets an opportunity to convince oneself, by the appearance of the image, that the different adaptations of the eye really depend upon alterations in the refractive media. One should cause to be fixed an object which is just about as far removed from the observed eye as the thread is from the flame. The observer then sees the elements of the retina and the image of the thread distinctly at the same time. Should the thread be carried nearer to or farther from the eye, then it becomes indistinct in the retinal image, or entirely disappears, while the parts of the retina remain sharp. One perceives from this that the retinal images of objects which stand at various distances from the eye, are in fact not equally distinct. Then again, one should so place the thread that it appears distinct in the retinal image at the same time with the vessels, and should cause the observed eye to fix a point which is either much farther or much nearer than that upon which it was formerly directed. Immediately one sees the retina and the image of the flame become gradually indistinct.

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*Probably the most significant sentence ever penned by an ophthalmologist. How gloriously the great man's prophecy has been fulfilled is known not merely to specialists and general practitioners, but even, in some degree, to first year medical students and the educated portion of the laity. In fact, there are just two kinds of ophthalmology, that which came before and that which followed after Helmholtz's "*Beschreibung eines Augenspiegels.*"—(T. H. S.)

It should incidentally be remarked that, on the white surface of the optic nerve no image is cast, even when the image appears absolutely sharp on the immediately surrounding portions of the retina. Inasmuch as the observer, in the case of a person over whose optic nerve cross-section little vessels run, sees these quite as plainly as those of the retina adjacent, therefore that indistinctness of the image of the flame cannot proceed from the passage of the end of the optic nerve out of the level of the retina. I believe rather that one must regard the transparent condition of the optic nerve mass as the real cause.

Moreover, one is able, whenever it becomes necessary, to convince oneself readily in an objective manner of the presence and the degree of the short- or far-sightedness of the observed eye. Let the observer first investigate a normal eye, which he causes to fix objects at various distances, and notice what concave lenses he is obliged to use in the various stages of adaptation of the eye. In the investigation of any other eye, he then learns from the number of the concave glass through which he saw the retina distinctly the corresponding adaptational distance of the observed eye. The observer is, by this method, entirely independent of the assertions of the other person, for he himself sees, as it were with that other's eye, at least by means of its refractive media. In this way, for example, I was able to convince myself in a completely amaurotic eye, that that eye was simultaneously in a high degree short-sighted. In that way was decided in this case a question of great importance for the anamnesis, whether, that is, certain earlier difficulties of sight recounted by the patient, should be referred to shortsightedness or to commencing amblyopia.

An important physiological conclusion thrust itself upon me in these investigations. The free-lying cross-section of the optic nerve is apparently so transparent that the light which falls upon it must penetrate deeply into the mass of the fibres, inasmuch as, now and then, one sees the bendings of the central artery and vein shimmering forward through the substance of the nerve. When the little image of the flame falls on the place of entrance of the nerve, then all its fibres, or at least a very large part of them, are struck by more or less intense light, and yet, obviously, they perceive no light. If they did perceive it, then that entire portion of the visual field which corresponds to them would have to appear illuminated. Not only, however, is that not the case, but there is even less light perceived than when the image falls upon some other portion of the retina. We must from this conclude that the fibres of the optic nerve are incapable of being affected by objective light (ethereal vibrations), while, never-

theless, they perceive every other kind of irritation as subjective light. This is a paradox, which, of course, has its ground in the ambiguity of the word "light," and is far removed from being an actual contradiction. The vibrations of the ether which we call light, produce, like every other mechanical or electrical irritation, when they strike the retina, the sensation which we call light. But from this, that the retina, protected from pressure and electrical currents and exposed to the action of ethereal vibrations, is much oftener struck and excited by the former than by the latter, it by no means follows that light must be regarded as an especially adequate irritant for the retina and the elements of the optic nerve and as standing in contrast to all the other kinds of irritation. There are no difficulties in supposing that all the irritations which are able to affect the optic nerve system produce sensations of light, that, however, the ethereal vibrations are able to act only on the retina. A similar state of affairs is found in the case of the nerves of touch, with respect to heat and cold. Here too the peripheral expansions behave differently from the trunks. For the latter, slight variations in temperature are no irritant at all, as it appears, and the greater variations, which are able to irritate, produce no temperatural sensations. Besides, one is able to conclude still further that, in the retina, not the fibres, which spread out in a radiating manner from the optic nerve, but the spherical elements, are sensitive to light. Were it the former, then must light which strikes on any place in the retina be perceived by all those fibres which in part end in this place, and in part pass across it on their way toward the retinal periphery. There would therefore extend, in the visual field, from every illuminated point, a bright shine toward the borders of the field, which is not the case. We may accordingly further conclude that even the continuations of the optic nerve fibres in the retina are insensitive to light. There remain only the ganglionic bodies and the nuclear-like structures of the retina, in which the ethereal oscillations are able to act as an irritant.

Appendix.

Derivation of the formula for the quantity of light which is reflected from several glass plates.

Whether this formula is correct for n reflecting surfaces is shown by the fact that it is also correct for $(n+1)$. As it also proves right for $n=1$ and $n=2$, it must do the same for any desired value of n.

Let the quantity of light which at the given angle of incidence is thrown back by a reflecting surface, when the quantity 1 passes off of

light polarized vertically against the plane of incidence, be p, that thrown back by n such surfaces $P_{(n)}$, that thrown back by $(n+1)$, $P_{(n+1)}$. It is demonstrable that if

$$P_{(n)} = \frac{np}{1+(n-1p)} \quad \ldots\ldots\ldots\ldots \quad 1)$$

then also that equation is correct which arises from this by the substitution of $n+1$ for n:

$$P_{(n+1)} = \frac{(n+1)p}{1+np} \quad \ldots\ldots\ldots\ldots \quad 2)$$

For the sake of a better designation, let us assume that the system of n reflecting plates lies horizontal and that light falls on it from above. Let the $(n+1)$ th surface be added to the system below. The quantity of light which passes downward from the lowermost nth surface of the compound system to the $(n+1)$ th surface let us call x; that which, reflected from the $(n+1)$ th surface, mounts to the system of the n surfaces, y. The quantity x is composed partly of the portion of the incident light which has passed through the system of n surfaces, partly of the portion of y which is reflected from this system. Therefore is

$$x = 1 - P_{(n)} + yP_{(n)} \quad \ldots\ldots\ldots\ldots \quad 3)$$

The quantity y originates from that part of x which is reflected from the $(n+1)$th surface. It is therefore

$$y = xp \quad \ldots\ldots\ldots\ldots \quad 4)$$

The quantity $P_{(n+1)}$ which passes upward from the uppermost surface, proceeds in part from that portion of the incident light which is reflected from the system of n surfaces, partly from that portion of y which passes through this system. It is therefore

$$P_{(n+1)} = P_{(n)} + y\ (1 - P_{(n)}) \quad \ldots\ldots\ldots\ldots \quad 5)$$

If one eliminates x and y from equations 3, 4 and 5, one gets

$$P_{(n+1)} = P_{(n)} + \frac{p[1 - P_{(n)}]^2}{1 - pP_{(n)}} \quad \ldots\ldots\ldots\ldots \quad 6)$$

If we place in this equation 6 the value of $P_{(n)}$ from equation 1, we get in fact, after the necessary reductions, equation 2, whose correctness was to be proved.

For *one* reflecting surface is

$$P_{(1)} = p \quad .$$

Equation one (to be tested) gives the same value.

For *two* reflecting surfaces we get the value $P_{(2)}$ without employing equations 1 or 2, if, in the derivation of equation 6, we suppose that $n = 1$ and ${}_{(n)}P = p$. Equation 6 then becomes

$$P_{(2)} = p + \frac{p(1-p)^2}{1-p^2}$$

$$= \frac{2p}{1+p}$$

Equation 1 gives the same value.

As the latter accordingly is correct for $n = 1$ and for $n = 2$, then it follows from the proof adduced, that it is correct also for $n = 3$, and if it is correct for $n = 3$, that it also is correct for $n = 4$, and so on to infinity.

In a precisely similar way the matter proceeds in the case of light polarized parallel to the surface of incidence.

If we assume the quantity of incident light to be equal to ½ J, and that $p = \frac{2P,}{J}$ and designate that which we have here called P with II, we get the formula in question.

The earliest reception of the ophthalmoscope is decidedly interesting. Thus, to quote from Koenigsberger, (*Hermann von Helmholtz*, p. 74, 1906): "The ophthalmoscope was, however, some time in making its way, on account of the mathematical and physical knowledge presupposed by the '*Description of an Ophthalmoscope for the Investigation of the Retina in the Living Eye*,' and people were at first very shy of employing it. One distinguished surgical colleague told Helmholtz he should never use the instrument—it would be too dangerous to admit the naked light into a diseased eye; another was of opinion that the mirror might be of service to oculists with defective eyesight—he himself had good eyes and wanted none of it."

The subsequent history of the ophthalmoscope down to a time within the memory of men still living is, very briefly, as follows: Ruete, in 1852, invented the "indirect method" (*D. Augenspiegel u. d. Optometer*, Göttingen, 1852). He, first, employed a *concave* perforated mirror, held at a considerable distance from the observed eye, and,

between the mirror and the eye, one (sometimes two) spherical convex lenses. Helmholtz, also, had made use of convex lenses, but these he had placed *behind* the mirror, finding them there, of course, of very little value. (See herein.)

Helmholtz next explained most thoroughly (*Vierordt's Archiv,* 1852, p. 827) the method which Ruete had invented. In the very same paper Helmholtz described what he called "the simplest method," by which an eye could be examined by means of only a candle, a screen and a convex spherical lens. He also mentioned (still in the same most memorable article) the so-called Rekoss discs, i. e., two rotatory discs, each containing four concave lenses inserted not far from the peripheries of the discs. One of the discs held lenses from 6 in. to 9 in. focus, the other those from 10 to 13 in. The Rekoss disc, or discs, with numerous modifications, is, as all are aware, in use at the present day. Rekoss was not an ophthalmologist, but an instrument-maker of Königsberg, where Helmholtz at the time was living.

Coccius, in 1853, invented an instrument which found much favor for years. It consisted of a lens, set in a frame, in front of a plane mirror. The distance between the mirror and the lens could be altered very considerably.

Eduard Jaeger, in 1854, produced a combination of the Helmholtz and the Ruete instrument—that is to say, the plates of silvered glass in the Helmholtz instrument were made replaceable by a concave silvered mirror, such mirror to be used for the indirect method. To this instrument of Jaeger, Strawbridge, of Philadelphia, in 1871, added three interchangeable Rekoss discs.—(T. H. S.)

THE MODERN OPHTHALMOSCOPE

For the methods employed in the *use of the modern ophthalmoscope,* see **Ophthalmoscopy**.

In a number of the later models—especially those of Ulrich, Freobelius and Myerstein—*prisms were employed as mirrors.*

Demonstration ophthalmoscopes. The attempt to enable two observers—generally teacher and student—to see the same fundus at the same time has already been discussed on p. 3814, Vol. V, of this *Encyclopedia.*

Stationary ophthalmoscopes. It must be remembered, that some of the earlier clinical instruments, like the so-called demonstration ophthalmoscopes, were mounted on stands—the patient and surgeon both being seated for the ophthalmoscopy. These models have long

been discarded as impractical. Examples of stationary ophthalmoscopes are described in this and other sections.

Binocular ophthalmoscopes. Numerous efforts have been made to obtain a binocular or stereoscopic view of the fundus. Among the early ones is that of Giraud-Teulon. None of them has so far been successful. See p. 969, Vol. II, of this *Encyclopedia.*

Refraction ophthalmoscopes. For a more complete account of the method employed in measuring the refraction provided in most modern models, see **Ophthalmoscopy.**

It may here be added that of the excellent practical instruments that have been invented during the past forty years for either (or both) direct or indirect determination of the refraction a few are not here described, e. g., the ophthalmoscopes of Cohn, de Wecker, Harlan and Snell.

In volume II, part 4, of the *Transactions of the American Ophthalmological Society,* p. 476, 1878, will be found John Green's description of his instrument, which he refers to as a modification of the earlier Loring. As Green was among the first Americans to interest himself in the history and mechanical details of the ophthalmoscope the following extracts from his notes will be appreciated by students of the subject.

Ophthalmoscopes fitted with a single or double disk, containing a number of lenses designed to facilitate the inspection of the fundus in the erect image, are among the earlier forms of the instrument. Helmholtz's ophthalmoscope with the Rekoss double disk, each disk with five openings and four concave lenses, giving a possible range of combination between minus $1/13$ and minus $1/3$, Donders' modification of Epkens' ophthalmoscope, with a single disk of seven openings containing the series plus 25, plus 12.5, plus 5, minus 6.25, minus 10, and minus 16.6 metric units are familiar examples.

Equally old is the idea of using the ophthalmoscope for measuring the refraction, and the series of correcting glasses furnished with some of the older instruments was quite sufficient for such rough determinations as were considered practicable. Jaeger's larger ophthalmoscope was furnished with the series minus $1/2$, minus $1/3$, minus $1/4$, minus $\frac{1}{5}$, minus $\frac{1}{6}$, minus $1/8$, minus $\frac{1}{10}$, minus $\frac{1}{12}$, plus $\frac{1}{12}$, plus $1/8$, plus $\frac{1}{6}$, plus $1/2$. Early in 1866 the writer had made, by Nachet, of Paris, a set of ophthalmoscope mirrors with clips admitting of the employment of the entire series of test glasses in the trial case, both spherical and cylindrical. A device similar to the last, but in an improved form, was exhibited by Dr. H. D. Noyes, at the meeting of the American Ophthalmological Society for 1869, and is figured

in the transactions of that year (p. 59). It is the best instrument known to the writer for obtaining a perfect view of the fundus of an astigmatic eye in the erect image. At a meeting of the American Ophthalmological Society for 1873 Dr. Knapp stated that some years before Dr. Loring constructed his instrument, he (Knapp) had a complete collection of small trial-glasses made which he could insert into an ordinary small (Leibreich) ophthalmoscope. The double-disk attachment of Rekoss to the original Helmholtz ophthalmoscope, and the pocket ophthalmoscope of Stellwag with its single disk of eight openings, containing the series plus $\frac{1}{2}$, plus $\frac{1}{6}$, plus $\frac{1}{12}$, minus $\frac{1}{12}$, minus $\frac{1}{10}$, minus $\frac{1}{8}$, minus $\frac{1}{4}$, minus $\frac{1}{2}$, exhausted most of the possibilities in the way of mechanical adjustments, but neither of these devices was intended or sufficed for accurate measurements of refraction.

The first practical ophthalmoscope designed for the measurement of the refraction is unquestionably that of Loring (*Trans. Am. Ophth. Soc.*, 1869; *Am. Jour. Med. Sciences*, Jan., 1874; *Trans. Am. Ophth. Soc.*, 1874; *Rep. Fifth Internat. Ophth. Congress*, 1876). which was first made with three interchangeable disks, and the introduction of this instrument marks also the beginning of the general employment of the objective method in the quantitative diagnosis of ametropia. Loring's first ophthalmoscope, though quite sufficient for the practical requirements of the ophthalmoscopist, has been considerably modified in form by its inventor and others. These changes have consisted chiefly in collecting the glasses from Loring's original three disks into a single disk or two disks. Thus Cohn (*Klinische Monatsblätter*, Oct., 1872) placed Loring's whole series of glasses in a single disk of inconveniently large size; de Wecker (*Ibid.*, Aug., 1873) placed the same series in a single small disk, but by so doing made the glasses inconveniently small; and Loring (*Am. Jour. Med. Sciences*, Jan., 1874), by an ingenious and novel arrangement, mounted the twenty-three glasses in one disk, but in two concentric circles, thus solving the problem of mounting a large series of conveniently large glasses in a conveniently small disk. Knapp also had one of Loring's instruments with the three disks in daily use during about four years, and produced a modification of it in which nearly the same series of lenses was mounted in two disks instead of three (*Trans. Am. Ophth. Soc.*, 1873; *Archives of Ophthalmol. and Otol.*, III., II., p. 2). See the cut. As an incident to this construction with two disks it was possible to use some of the weaker glasses of each disk to fill the large gaps between the higher numbers of the other, but the instrument did not realize the possibilities of a combination

ophthalmoscope, either in economy of lenses or regularity of intervals. As now constructed, it is a much more elegant and more convenient instrument than it was in the beginning.

The author's ophthalmoscope is based upon one of the earlier forms of Loring's instrument, which was an arrangement of twelve selected glasses in a single disk of thirteen openings, was made by Loring as a cheap and simple ophthalmoscope for students, and the instrument has been made and kept on sale by Hunter since 1871. The ophthalmoscope was made for the writer, in the summer of 1876, by Hunter, of New York. See the accompanying cut. The hinged mirror is taken from a later ophthalmoscope also by Loring, and made by Hunter. This mirror, mounted in a cell which is arranged to rotate in its own plane, appears to the writer to be on the whole preferable to the tilting mirror which is furnished with Loring's later instruments. The special feature in this instrument taken as a model is the rotating disk of thirteen openings, in which are mounted twelve correcting glasses, six of which are convex and six concave. The writer has placed in this disk a series of lenses in regular progression, and has added a second disk, of five somewhat larger openings, in which four additional glasses are mounted.

A second arrangement of lenses, based upon the metre-lens as the unit, is shown.

Astigmatism,* in the eye of the observer, is so serious a hindrance to rapid and accurate ophthalmoscopic investigations as to call for some arrangement by which the glass or glasses needed for its correction, in any particular case, may be made a part of the instrument. probably the most convenient mounting for these glasses is in a plate covering the second disk, and turning independently upon its pivot. It is well to make these glasses a little larger than those of the disk upon which they are superimposed, and they are shown in the figure of a diameter of eight millimetres, the lenses of the second disk, those of the principal disk, and the opening in the mirror measuring six and a half, five, and three and a half millimetres respectively. A fixed covering plate may be used in the place of the revolving plate whenever the correcting glasses for astigmatism are not required.

* The correction of astigmatism is of importance to all observers with optical instruments, as low a degree as 1/60 materially detracting from the sharpness and quickness of perception, and so confining an otherwise excellent observer to an inferior rank. This is especially true in the case of astronomical observers, who must combine accuracy with quickness of perception in the highest degree. The correcting-glass, which in most cases may be a simple cylindrical lens, either convex or concave, may be set in a cap or short tube, and placed over the eye-piece at the pleasure of the observer.


FIG. 4.

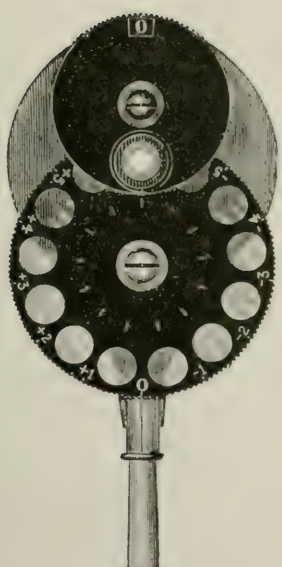


FIG. 5.

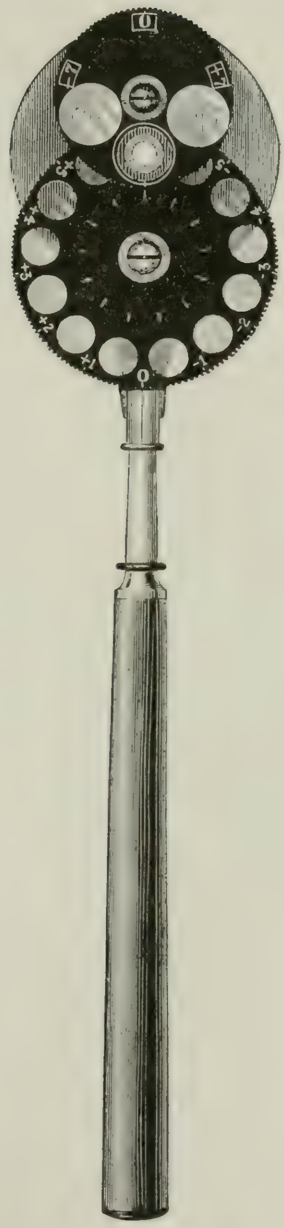


FIG. 6.

John Green Ophthalmoscope.

The principal disk hardly needs to be covered, as the glasses are perfectly accessible, and can be easily wiped if they become soiled.

A ratchet mechanism for accurately centering the lenses, as in the original Rekoss disks and in most of the recent disk-ophthalmoscopes, is often very convenient, by enabling the observer to change the glasses without removing the instrument from his eye. A rather long handle, as shown in the cut, is much more convenient than a shorter one. The disk is, however, not easily reached by the finger of the hand holding the instrument. This inconvenience has been quite ingeniously overcome by Loring, in an instrument of which no account has yet appeared in print, by cutting teeth in the circumference of the disk, and thus making it articulate with a second toothed wheel of the same or lesser size placed below it upon the handle.

The figures in the text show the ophthalmoscope, fitted with a fixed covering plate, and with the revolving cover, in which two correcting glasses are set. Its weight, exclusive of the long handle, is exactly twenty-eight grammes.

This ophthalmoscope, substantially as described, was made in the summer of 1876, and was shown to many members of the International Ophthalmological Congress in attendance at the meeting of that body in New York. In consequence, however, of the absence of the writer from the final session of the Congress, it was not publicly shown, and was not noticed in the *Transactions.* This explanation is called forth by the fact that the writer has but lately (July, 1878) become acquainted with a new and as yet undescribed combination ophthalmoscope by Dr. Loring, which, had it existed earlier, would have rendered this one superfluous. The two instruments, as might be expected in the case of independent productions, differ in form and in some matters of detail—differences which are perhaps sufficient to excuse this somewhat tardy publication.

Electric ophthalmoscopes. This subject has been discussed on pp. 4230 and 4754, Vol. VI, of this *Encyclopedia,* as well as under De Zeng in this section. It may be repeated here that the U-shaped mirror probably secures the greatest reflecting surface, and has an aperture with no upper edge to reflect light into the examiner's eye.

In using the instrument by the direct method, the lamp is first moved up as far as possible by means of the corrugated band. For use in the indirect method, hold at the usual working distance and move the light up or down until the reflection on the patient's head is a long narrow bar of light; interpose the lens, and a good inverted image of the fundus is obtained.

The reflection of the lamp as seen in the mirror should be vertical,

as in Fig. I, and not horizontal, as in Fig. II. To make this adjustment, turn the handle while holding the body of the instrument stationary.

The chief claims made for the *self-luminous electric ophthalmoscope* are: illumination of the entire fundus; no reflex from the aperture; adjustable focus; may be used in the indirect method; can be used for

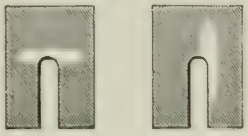


Fig. I. Fig. II.
Split, U-Shaped Ophthalmoscopic Mirror.

ward and house-to-house examinations much more easily than the extra-luminous electric or older model of ophthalmoscope.

Binocular ophthalmoscopes have not proved very satisfactory. See p. 969, Vol. II, of this *Encyclopedia.* The theory of the Ohm instrument is illustrated under the proper alphabetical heading.

Modern ophthalmoscopes. Although the clinical instruments now in use, including the so-called refraction ophthalmoscopes, are mostly evolved from the earlier devices of Babbage, Helmholtz, Coccius and Liebreich, yet they are all decided improvements upon these early models. We are indebted chiefly to Loring for his double disk and two rows of lenses, to Wadsworth for the obliquely set mirror and to Couper and Morton for the endless chain of lenses. The self-luminous *electric* ophthalmoscope (See p. 4230 and p. 4754, Vol. VI, of this *Encyclopedia*) is now in the hands of every ophthalmologist, and in many cases is to be preferred to the older models.

In addition to those instruments described and pictured elsewhere in this *Encyclopedia* a number of others (it is impossible even to mention, much less to describe, them all) are (*in alphabetical order*) here depicted.

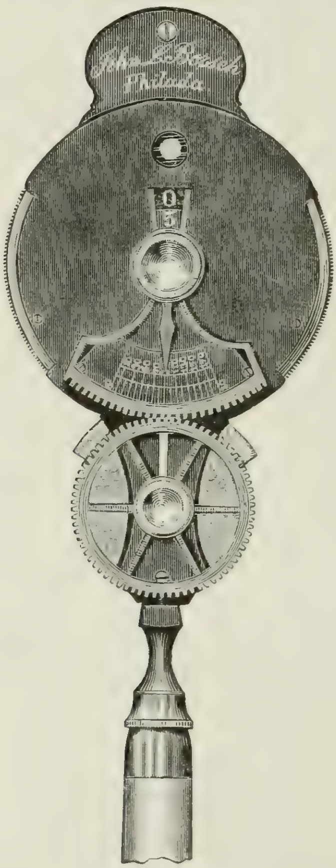
For methods of using these instruments, and their special applications, see, also, **Ophthalmoscopy**; as well as p. 4760, Vol. VI of this *Encyclopedia.*

Ando ophthalmoscopes. This inventor (*Nippon Gank. Zasshi,* Aug., 1912) has devised several ophthalmoscopes. They are worthy of notice mainly because they draw attention to three varieties of the instrument, viz., (1) the *fixed instrument for the indirect* method, (2) a form adapted to the use of the *acetylene light,* and (3) a form capable

of being used in *direct sunlight.* The reader is referred to the original paper for a description of these models.

Baum electric ophthalmoscope. See p. 914, Vol. II, of this *Encyclopedia.*

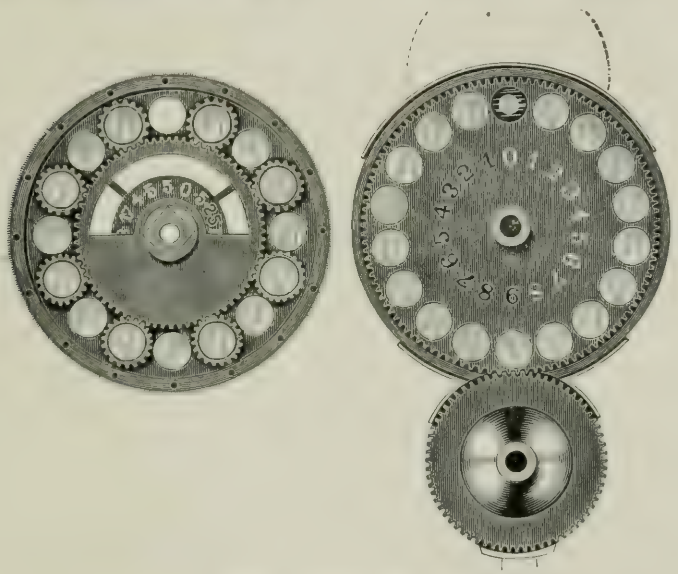
Beale ophthalmoscope. This instrument was invented about 1860 by Lionel Beale, and was devised for the purpose of examining the



Borsch Ophthalmoscope. I.

ocular fundus without darkening the room. The inventor found it of considerable value in the dimly-lighted wards of the hospital. Soelberg Wells was able to see the fundus details perfectly in broad daylight, and thus describes the instrument: The reflector and lens are enclosed in a tube to the side of which is adapted a small paraffin lamp, with a large plano-convex lens. The illumination is so strong that it is not necessary for the tube to fit accurately to the margin of

the orbit; indeed, the instrument can be used quite successfully even if two or three inches traversed by daylight intervene. The reflector is fixed in the tube at the proper angle, and the lens is made to incline a little, so as to remove the reflections upon the retina out of the field of vision. With this instrument the optic disk is at once brought into view without any difficulty, and as the lamp moves with the mirror and lens, inexperienced persons can use the apparatus successfully almost upon the first trial. The instrument weighs nearly a pound, but it can be made very much lighter. The lamp is the same as that which Beale adapted to the hand microscopes he used for the demonstration of objects in his lectures. For making ophthal-



Borsch Ophthalmoscope. II.

moscopic drawings, the instrument can be fixed to a pillar and stand. The artist can work in daylight with very little effort, while the patient can retain the eye fixed in the proper position without exertion.

Borsch ophthalmoscopes. The accompanying cuts give a good idea of the mechanical details of these instruments.

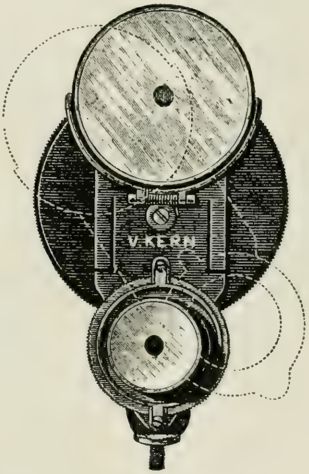
Burow ophthalmoscope. This instrument is described in Vol. I, pt. 1, p. 121, of Graefe's *Archiv.* It resembled previous instruments except that the mirror took the form of a silvered bi-convex lens. This inventor (Graefe's *Archiv für Ophthalm*, III, 2, p. 76) was probably the first to employ an instrument with a convex lens held in one hand

between the ophthalmoscope and the examined eye, in other words to put into practice the well-known indirect method of the present day.

Chevallereau ophthalmoscope. See the illustration accompanying this text.

J. Herbert Claiborne (*Trans. Am. Oph. Soc.*, p. 150, Vol. XIV, 1915) describes a form of the electric ophthalmoscope ingeniously contrived of what he regards as the most useful parts of the Dennett-Crampton-May-Marple instruments.

Couper ophthalmoscope. It is to the inventor of this model that we are indebted for the chain of lenses so well known in the (subsequent) Morton instrument. See the figure.



Chevallereau Reversible Mirror Ophthalmoscope.

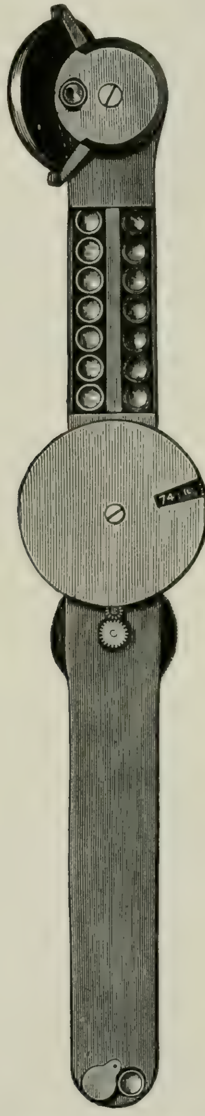
Crampton-Loring ophthalmoscope. George S. Crampton, who first proposed the handle battery, has demonstrated a simple modification of the Loring ophthalmoscope which is described on p. 4749, Vol. VI, of this *Encyclopedia.*

Croskey ophthalmoscope. The accompanying cuts furnish a satisfactory idea of this instrument.

Dennett ophthalmoscope. See the subsection *Electric ophthalmoscopes,* as well as p. 4230, Vol. VI. of this *Encyclopedia.*

De Zeng ophthalmoscopes. The various electric ophthalmoscopes invented and improved by this ingenious observer have been mostly described and depicted under several captions, but especially on p. 4230, Vol. VI, of this *Encyclopedia.*

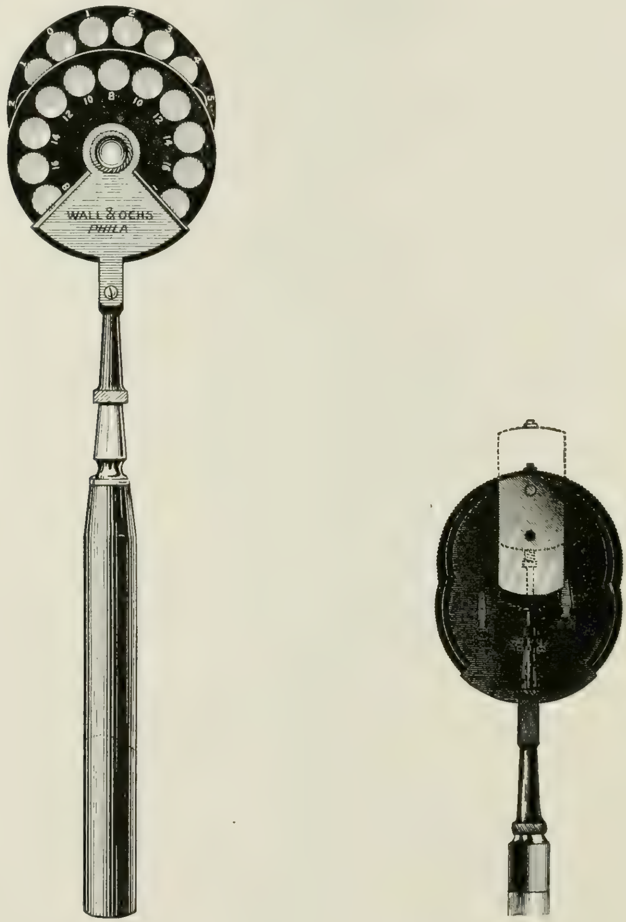
The most recent model is a small but effective Loring instrument provided with a handle battery, a "split" metallic mirror, means of



Couper Ophthalmoscope.

regulating the illumination and various other improvements that appeal to the ophthalmologist who needs a reliable instrument for all kinds of ophthalmoscopy.

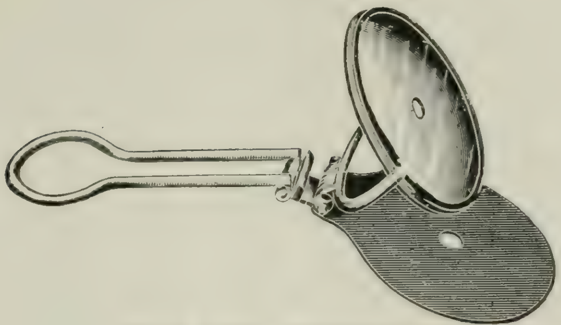
Epkens ophthalmoscope. This instrument deserves special mention because, although among the very earliest forms (Dec., 1851) it was the first that was provided with a silvered mirror from the center of which a portion (oval in form) of the silver had been removed, and through which the observer viewed the fundus oculi.



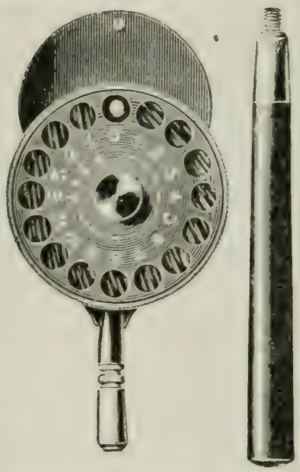
The Croskey Ophthalmoscope.

Eversbusch ophthalmoscope has fifteen lenses, including 1 to 12 D. concave and 1 to 6 convex.

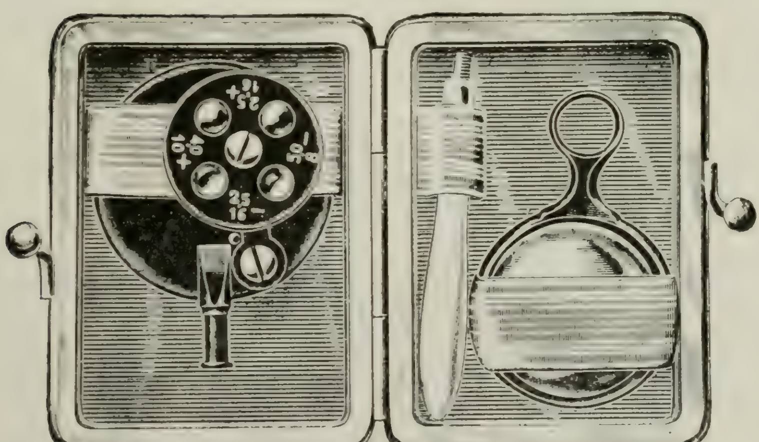
The Follin ophthalmoscope has four correcting lenses mounted in a revolving disk so that each of them may be brought in front of the lens aperture of the instrument.



Essard Pocket Ophthalmoscope.



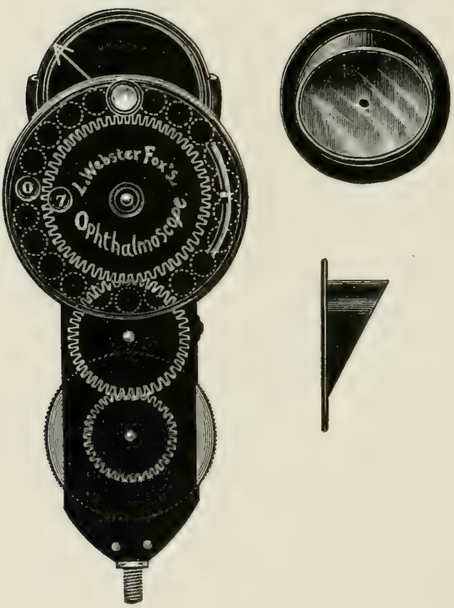
Eversbusch Ophthalmoscope.



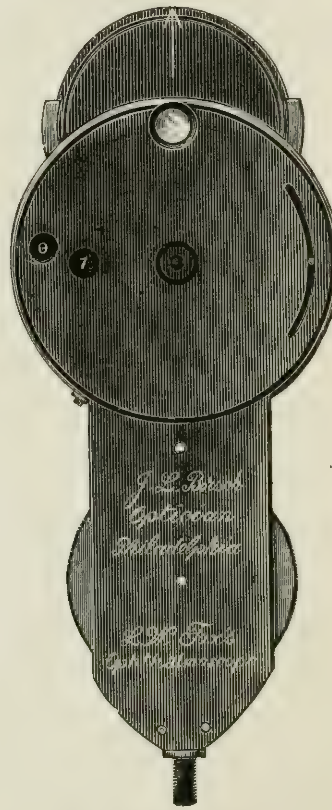
Follin Ophthalmoscope.

In another Follin ophthalmoscope—of the earlier type—the mirror and the collecting lens were stationary. See the figure.

Webster Fox ophthalmoscope. The main features of this ophthalmoscope are the toothed-wheel mechanism, the short focal length of the mirror for direct examination, and a large combination of lenses. There are two mirrors with focal lengths of 8 centimetres and 20 centimetres respectively, which are set obliquely and can be rotated to any angle. See the figure.



Fox Ophthalmoscope. I.



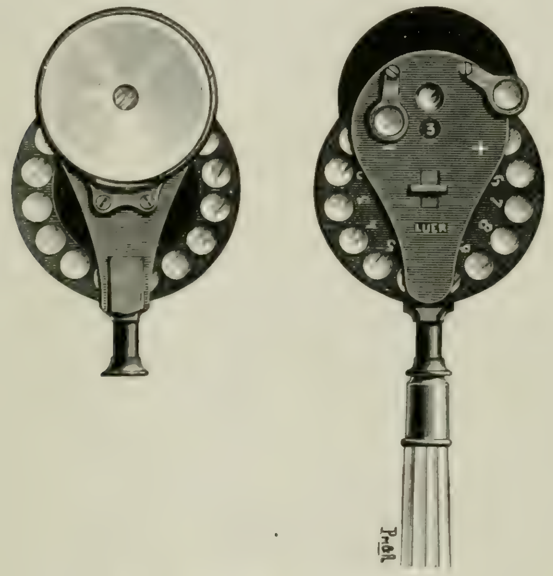
Fox Ophthalmoscope. II.

In the direct method of examination by this instrument the rays from the short focal mirror intersect each other in the crystalline lens, giving rise to an evenly diffused brilliant circle of illumination, instead of an inverted image of the lamp on the retina, so common with the ordinary ophthalmoscope.

An arrow placed upon the back of the mirror indicates the angle at which it is set. The proper position of the angle during an examina-

tion is about 25 degrees above the horizontal, with the arrowhead pointing towards the lamp. This allows the handle of the instrument to be thrown away from the patient's face and the index wheel can be easily rotated.

The short focal mirror is used in examination by the direct method to determine the refraction and pathological changes in the cornea, lens, retina, and choroid. In very high myopia the illumination may be fainter than usual, but this may be readily overcome by lessening the distance from the lamp to the mirror. The long focal mirror is



The Galezowski Ophthalmoscope.

employed when the illumination by the short mirror is insufficient, as in very high myopia, in retinoscopy, and in the indirect method.

The diameter of the disk is 42 millimetres, and has 22 apertures, admitting 10 convex and 11 concave lenses. Added to this is a crescentic segment of a disk with 5 apertures containing 4 lenses. This allows, by combination, 33 convex lenses ranging from 0.5 D. to 22 D. and 42 concave lenses ranging from 0.5 D. to 35 D.

The lenses are brought to the sight-hole by an inclosed system of 3 toothed wheels; the first is set on the disk, the second is placed between the disk-wheel and the finger-wheel, and the third is the lowest, or finger-wheel, the milled edge of which projects far enough to allow

the index-finger to rotate it. Each lens is accurately centred with the sight-hole on the mirror by a spring action.

Fröbelius ophthalmoscope. This "prism" instrument was of the Coccius type and appeared shortly after that inventor described his ophthalmoscope.

The Galezowski ophthalmoscope operates three mirrors, one tilting, concave (of short range) for the erect image, and two others, one concave for the inverted image and the other plane; also a single disk with two concentric rows of appropriate plus and minus lenses. See the illustration.

This inventor (*Bulletin. de l'Accdémie de Méd.*, Jan., 1862) devised also an instrument somewhat like the early model of the Follin scope, in which the lens and the mirror were placed at the two ends of a telescopic tube.

Galezowski's stationary, or in part stationary, *ophthalmoscope* did not much differ from the similar instruments of Hasner, Donders and Liebreich. It is fully described in de Wecker's *Études ophtalmologiques,* Vol. II, p. 81.

For the first time one finds the claim made for these partially stationary instruments—in which one hand holds the movable converging lens—that the arrangement does not require a darkened room and that the examination can be made of a patient lying in bed, advantages that are now found in the self-luminous electric ophthalmoscope.

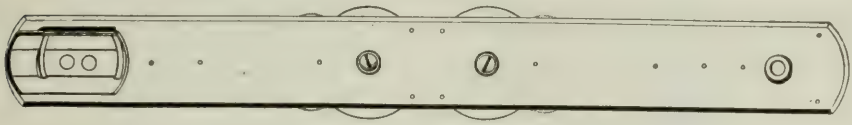
Gamble-Loring folding ophthalmoscope. See p. 4751, Vol. VI, of this *Encyclopedia.*

Geneva retino-ophthalmoscope. This device is a combined retinoscope and ophthalmoscope (inverted image), and is especially useful for teaching purposes, as the fundus is with it readily seen by beginners. See p. 4726, Vol. VI, of this *Encyclopedia.*

Golowin ophthalmoscope. This observer (*Klin. Monatsbl. f. Augenheilk.,* Sept., 1911), has devised a mirror for his ophthalmoscope which has a crescentic area cut away from one side from which the operator obtains his view of the fundus. The half-moon opening is directed to the nasal side. Provision is made for the attachment of lenses, if desired, for high errors of refraction. The writer thinks that the inexperienced can more quickly become conversant with the eye ground examination by its use.

Gould ophthalmoscope. The lenses in this ophthalmoscope are arranged in two series, those most used at one end, and the higher numbers both plus and minus, at the other. There are sixty lenses,

all the lower powers proceeding from zero by 0.5 D. intervals; the highest minus lens being 40 D., the highest plus, 30 D. See the cut.



Gould Ophthalmoscope.

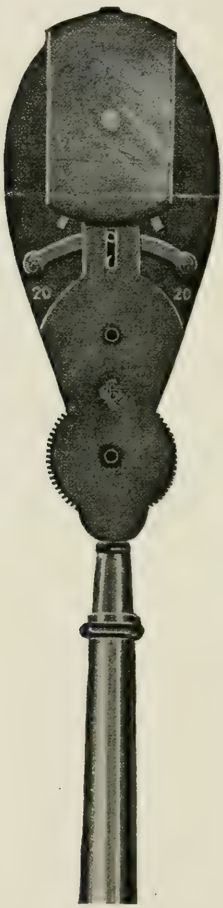
Graefe and Peppmüller ophthalmoscope. This was one of a rather large class of demonstration ophthalmoscopes; a description of it was first published in 1877. The rays of light intended for the person for whom the demonstration was made are reflected by a small piece of mirrored glass (placed on a larger mirror) at the side of the opening.

John Green ophthalmoscope. For a complete description (accompanied by a cut) of this instrument see under the sub-section *Refraction ophthalmoscopes* (supra).

Gullstrand's Monocular Hand Ophthalmoscope.

Gullstrand (hand) ophthalmoscope. In addition to his larger (reflexless) instrument (described on p. 4758, Vol. VI, of this *Encyclopedia*) this observer has invented a monocular hand instrument by him said to be devoid of the troublesome corneal and other reflections that

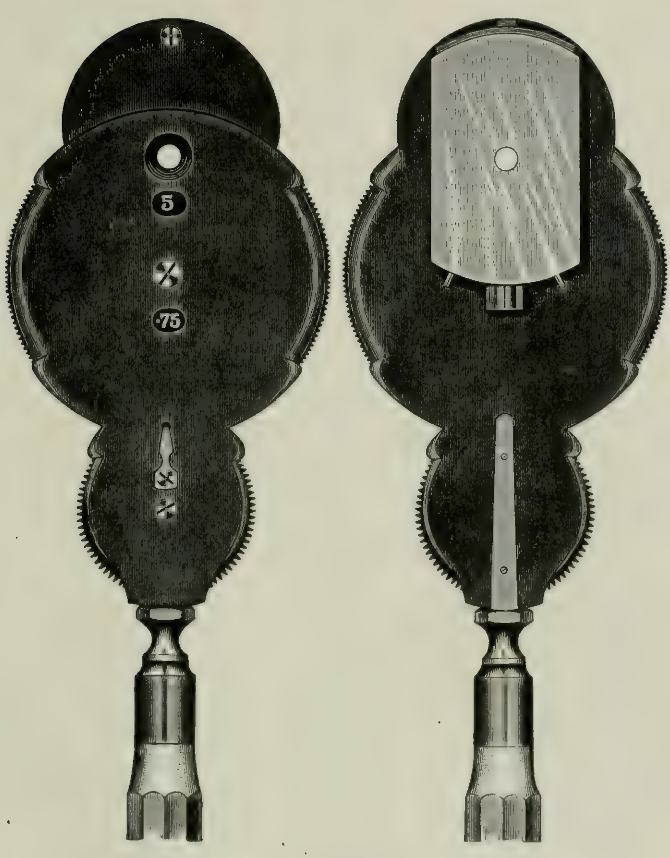
often annoy the examiner. In using it only two unimportant reflections at the surfaces of the ophthalmoscope lens are noticeable, and these do not affect appreciably the value of the instrument. The illumination is from a small electric lamp with a straight filament, which, through the medium of a rheostat, may be fed from the electric



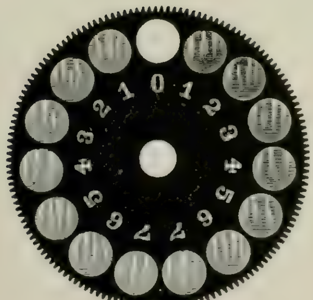
Hare's Ophthalmoscope.

Hare's Electric Ophthalmoscope.

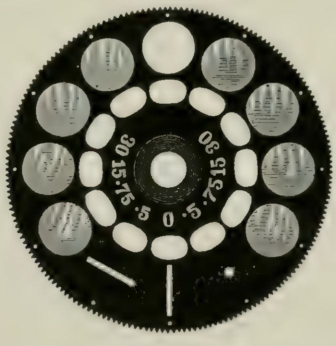
house supply, or from an accumulator. The ophthalmoscope lens, which is aspherical and has a focal length of 6 cm, forms in the patient's pupil an aplanatic image of the diaphragm opening as well as the luminous slit. To obviate the occurrence of disturbing reflections it is necessary in the case of very narrow pupils to provide the ophthalmoscope lens with a slit-like diaphragm.



Harlan Ophthalmoscope. I.



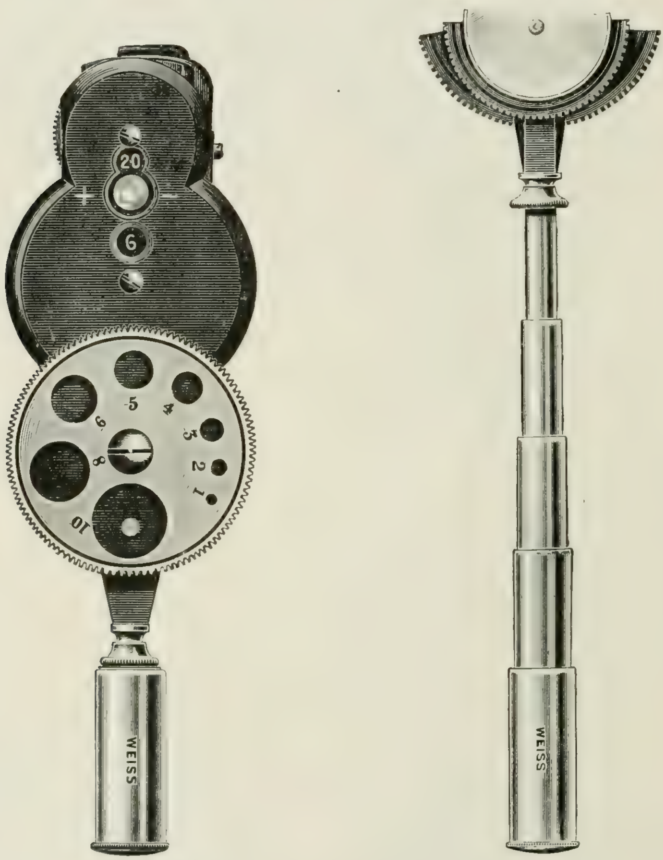
Harlan Ophthalmoscope. II.



Harlan Ophthalmoscope. III.

The instrument is fitted with a Rekoss disc, by means of which lenses of different powers may be introduced in front of the diaphragm. This affords a means of varying the magnifications of the ophthalmoscopic image.

The strengths of these lenses, as supplied for an emmetropic eye, range from + 2 to + 10 D. Ametropic observers wishing to dispense



Bishop Harman Ophthalmoscope.

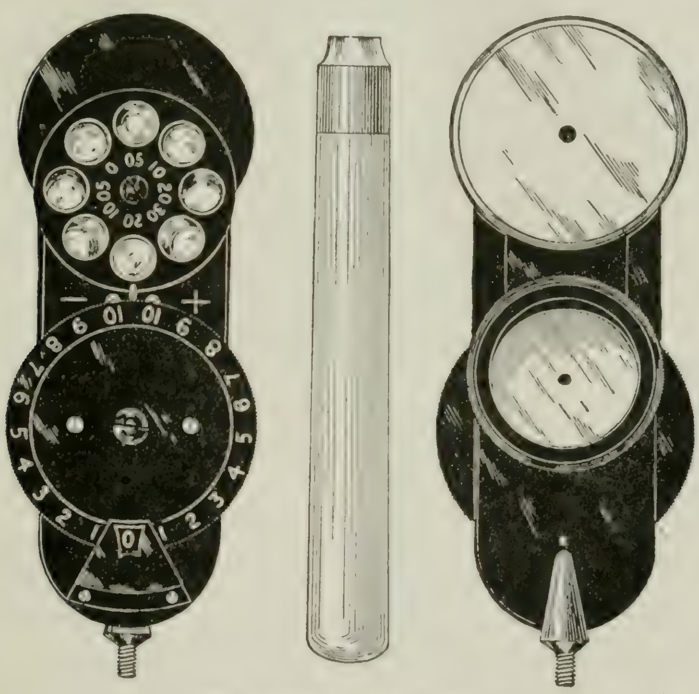
with their spectacles when using the ophthalmoscope may have the Rekoss disc fitted with lenses adapted to their sight; or the diaphragm may be fitted with a glass corresponding to the observer's error. See the figure in this text.

Hale's ophthalmoscope. See p. 4754, Vol. VI, of this *Encyclopedia*.

Hare's ophthalmoscope, including the self-luminous or electric model, is one of the best and most complete of modern instruments, combining

facility of use with a supply of a large number of readily controlled plus and minus lenses. See, also, p. 4751, Vol. VI, of this *Encyclopedia,* as well as the figures in this text.

Harlan ophthalmoscope. In this instrument an endeavor has been made to combine, as far as possible, the advantages of the Loring, Knapp, and Noyes ophthalmoscopes, and several additions and some changes have been made in the mechanism. There are two discs, one placed directly over the other. The principal disc has seven plus and seven minus lenses, with intervals of one diopter, and is rotated by

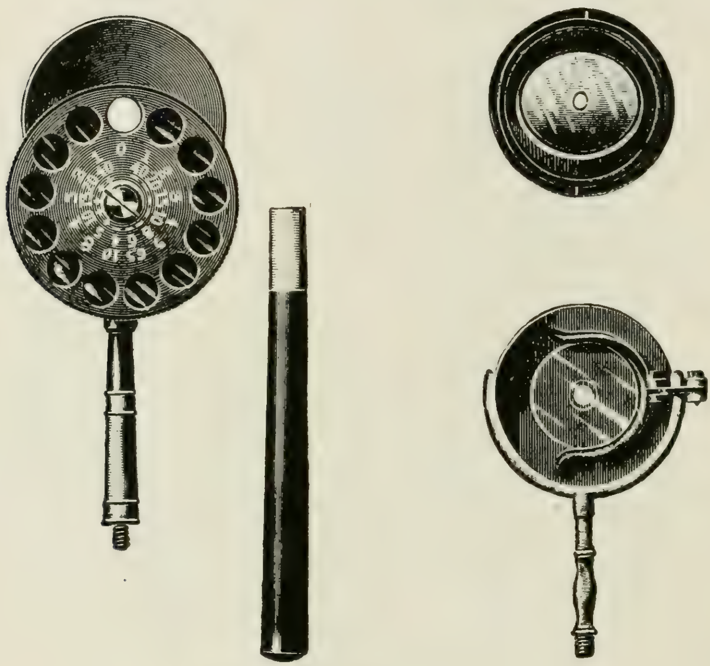


The Hawes Ophthalmoscope.

means of a small cog-wheel placed at the lower end of the instrument. The supplementary superimposed disc contains plus and minus lenses of .50, .75, 15., and 30. D., and is rotated by means of its serrated edge. This gives lens combinations with an interval of $\frac{1}{4}$ D. from .50 to 7. D.; and with an interval of 1. D. from 7. to 37. D. The lenses are protected by a metallic cover. The instrument is also furnished with stenopaic slits $\frac{2}{3}$ of a millimetre in width, at angles of 90°, 180°, 45°, and 135°, which can be brought by rotation in front of any of the

lenses in the principal disc. The Wadsworth tilting mirror is employed. See the illustrations.

The Bishop Harman ophthalmoscope has a double mirror, pupilometer, scotometer, color tests and telescope handle. According to the *Lancet,* Oct., 1909, this instrument has a range of 70 D, but when closed measures only 3⅛ ins. by 1¼ ins. by ⅜ in.; its weight, including case, is under 2½ ozs. It is therefore the smallest complete refraction ophthalmoscope yet devised. See the figure.



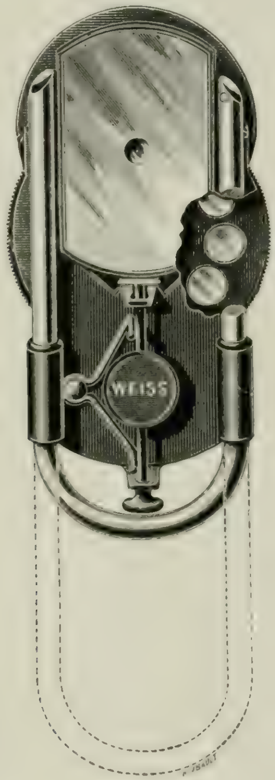
Hirschberg's Ophthalmoscope.

Hasner ophthalmoscope. This instrument (of the larger, partially-stationary variety) belongs to the same class as the larger Galezowski and Liebreich scopes. See Hasner's *Klinische Vorträge über Augenheilkunde,* p. 83, 1860.

Hawes ophthalmoscope. This is a modification of the Morton instrument and contains a chain of lenses from 1 to 10 D, both minus and plus, giving the whole range of refraction lenses from 1 to 10. A secondary disc is armed with + 0.5, 10 and 20; also with practically the same concave lenses. It has a hinged attachment for two mirrors, as depicted in the accompanying figure.

Hirschberg ophthalmoscopes. One is of the simple type, with an oblique plane, mirror, a Rekoss disk, 12 concave and five convex lenses. Compare the figure.

In another model—a modification of the Schnabel instrument—Hirschberg places one disk above the other so that, alone and in combination, twenty-five lenses are available.

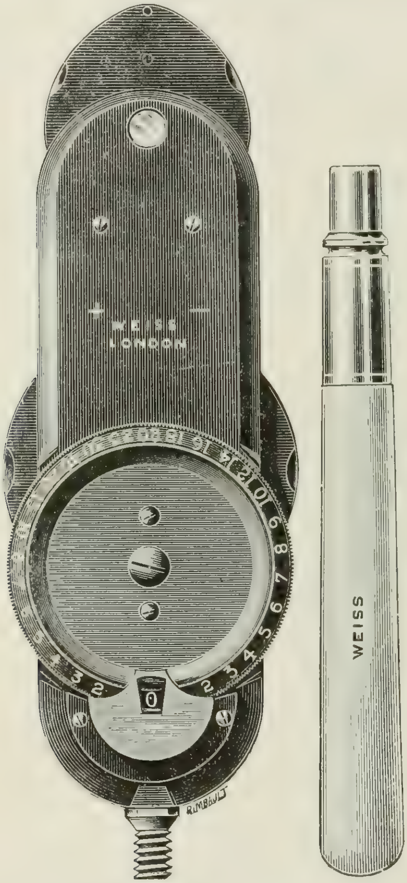


FULL SIZE

The Jessop Ophthalmoscope.

Edward Jackson ophthalmoscope. The form of this ophthalmoscope is illustrated in the cut. The mirror is swung upon a pivot, placed at each end, so that it can be tilted to an angle of 25 to 30 degrees with the back plate that shades the surgeon's eye from the light. The aperture in the mirror is about 2 millimeters in diameter. The lenses are arranged in two slides just behind the mirror. They are moved by the tip of the forefinger acting on milled projections from the lower ends of the slides. This allows the use of all lenses and combinations of lenses of which the instrument is capable without re-

moving it from the eye. By taking out a screw from the lower end of the stem, the slides of lenses are readily removed for cleaning. The lens series furnished by the instrument includes either convex, 1, 2, 3, 4, 5, 6, 8, 11 and 15 D; and concave 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, and 30 D.; or convex, 0.5, 2, 1.5, 2, 2.5, 3, 3.5, 4, 7.5, and 10 D.; and

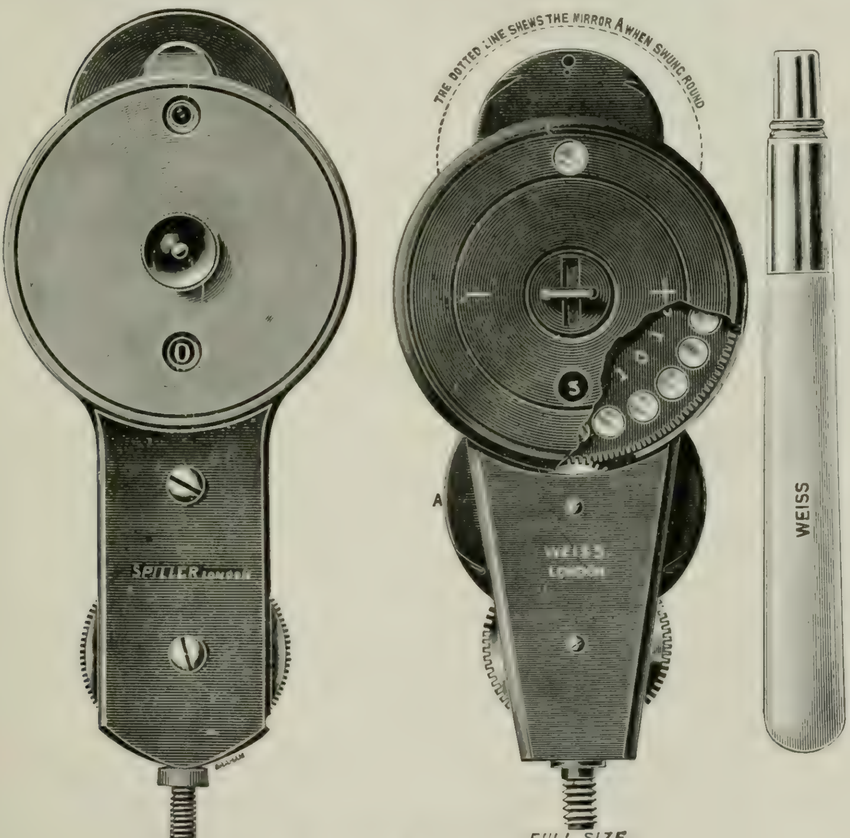


FULL SIZE
The Lindsay Johnson Ophthalmoscope.

concave, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, and 25 D. Either series is sufficiently complete for all practical purposes; but the former is preferable, the 0.5 D. intervals being of no value except to the expert who is constantly measuring refraction with the ophthalmoscope.

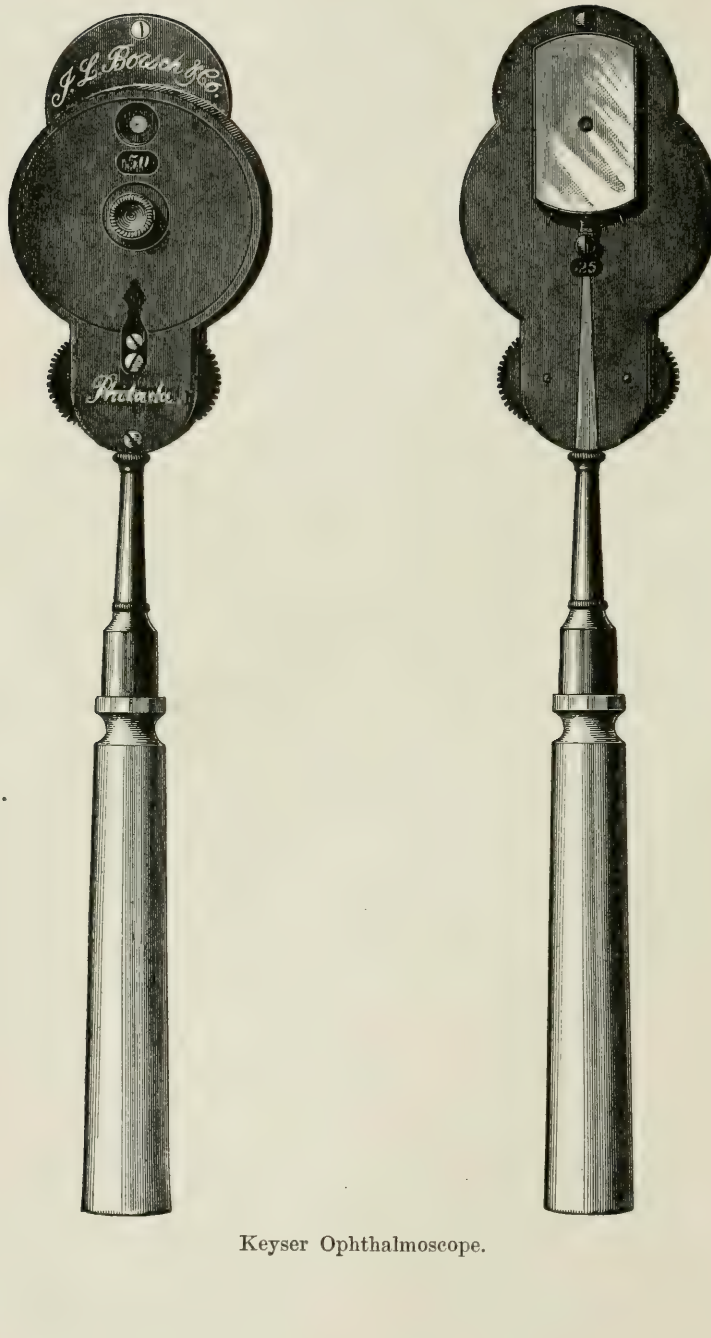
The Jessop ophthalmoscope has a tilting mirror, five concave and six convex lenses. It can be readily carried in the pocket and weighs but little. See the cut.

The Lindsay Johnson ophthalmoscope is similar in principle to the Morton instrument, but has an improved driving arrangement which allows the lenses to be brought opposite the sight hole with more rapidity. It has the swinging mirror fittings, as in the Morton and can be supplied with either two or three mirrors, with metal handle, fitted with color test and pupilometer and a 2-in. condensing lens. See, also, p. 4751, Vol. VI, of this *Encyclopedia*. See the figure.



The Juler Ophthalmoscope.

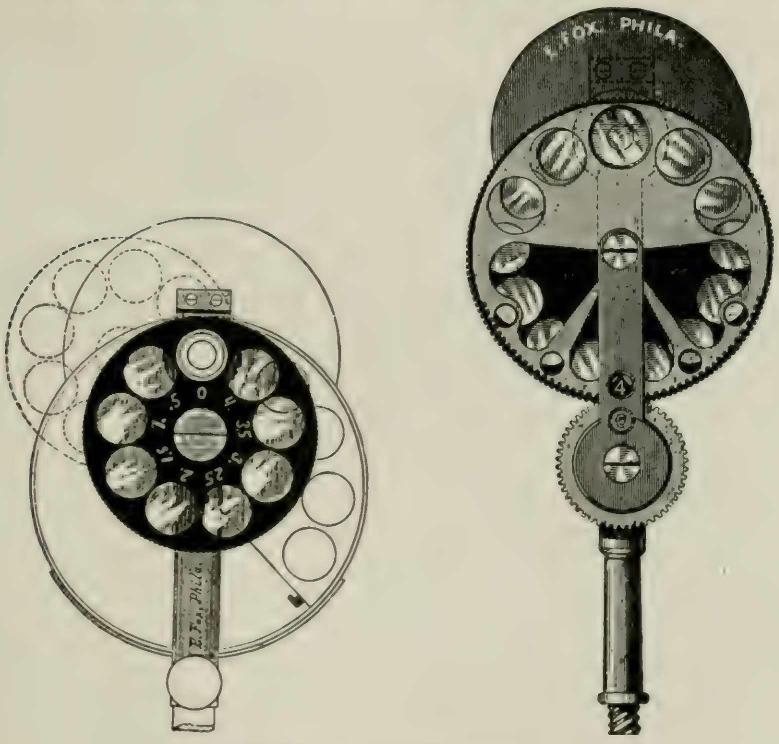
The Juler ophthalmoscope consists of a wheel containing 24 lenses enclosed in a metal case, and propelled by a wheel conveniently placed over the handle. It has the swinging mirror fitting similar to Morton's, with a large concave mirror and small revolving angle mirror for direct examination. It is also fitted with two inch condensing lens, metal handle with pupilometer and color test. This instrument can also



Keyser Ophthalmoscope.

be fitted with an (extra) plane mirror similar to Morton's. Compare the illustration.

Keyser ophthalmoscope. This instrument has the advantage of being among the lightest disc ophthalmoscopes, and one of the smallest made. It has two discs, either of which can be revolved easily with the thumb and index finger while holding the instrument. One disc contains plus lenses 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 10, 12 and 16;



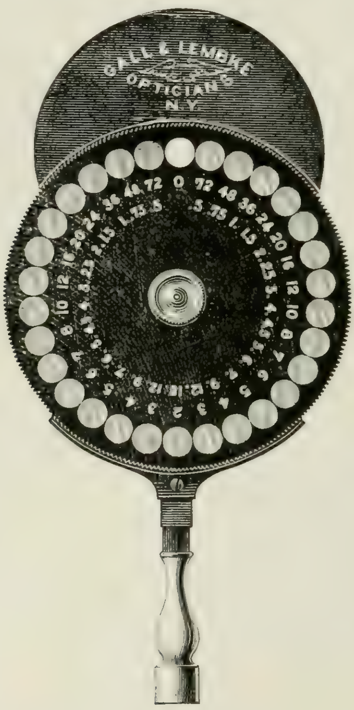
The Keyser Ophthalmoscope.

the other, minus lenses 0.25, 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 10 and 16. Any combination of these lenses may be made without removing the instrument from the eye. See the accompanying figures.

Klaunig' ophthalmoscope. This is one of the early hand instruments of the smaller Jaeger type in which a number of separate layers of glass were employed, as in the original Helmholtz ophthalmoscope. See the author's description (Ein neuer Augenspiegel in the *Deutsche Klinik,* No. 16, 1854).

Klein ophthalmoscope. In this instrument the lenses are made of "euradion" glass of yellowish tint; or before whose lenses euradion

glass is placed. This device is intended to cut off the ultra-violet rays, and thus give ocular comfort during the examination of the fundus. The inventor also claims to have noticed a "lessening tendency to produce contraction of the sphincter muscles of the iris and of the ciliary muscles." He also believes that in the employment of his instrument "the edge of the retinal reflection is sharper and clearer, a result which is to be expected when a monochromatic



Knapp Ophthalmoscope.

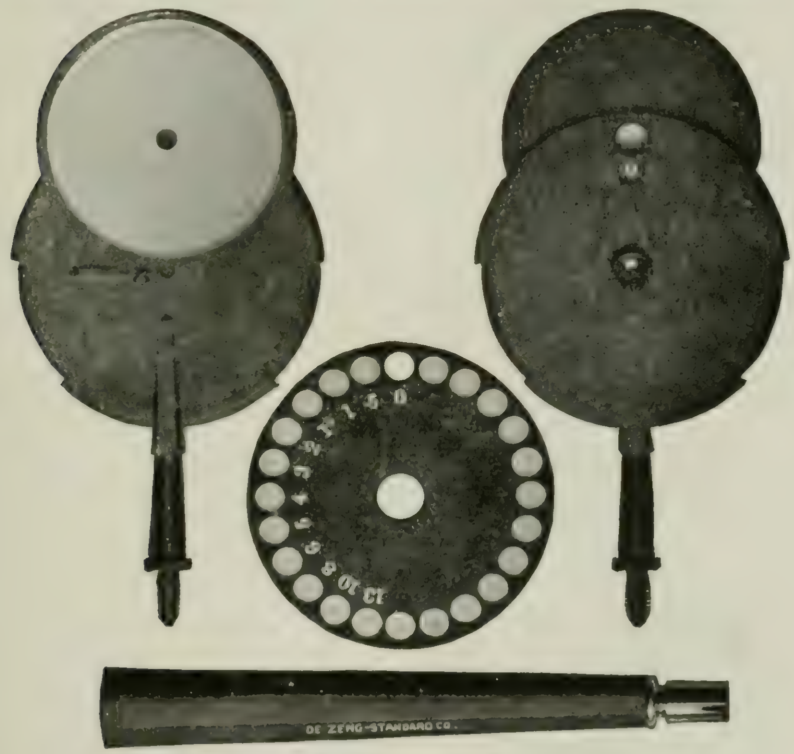
light is used, of which yellow, because of its brightness and intensity, is undoubtedly the best."

Knapp ophthalmoscope. See the beginning of the section, as well as the figures here.

The Knauer ophthalmoscope has two discs, the lower operated by a small driving wheel. This disc again acts automatically upon the upper disc in such a manner that the consecutive combinations are effected automatically in intervals of 1 diopter from + 1. D. to + 20. D., and from — 1. D. to — 39. D. Situated behind the tilting mirror is a slide containing a + .5 D. lens, which can be brought

in combination with any of the lenses in the series by a movement of the index finger, thus giving a regular interval of .5 D. from + .5 to + 20.5 D., and from — .5 D. to — 39. D., making in all 119 combinations.

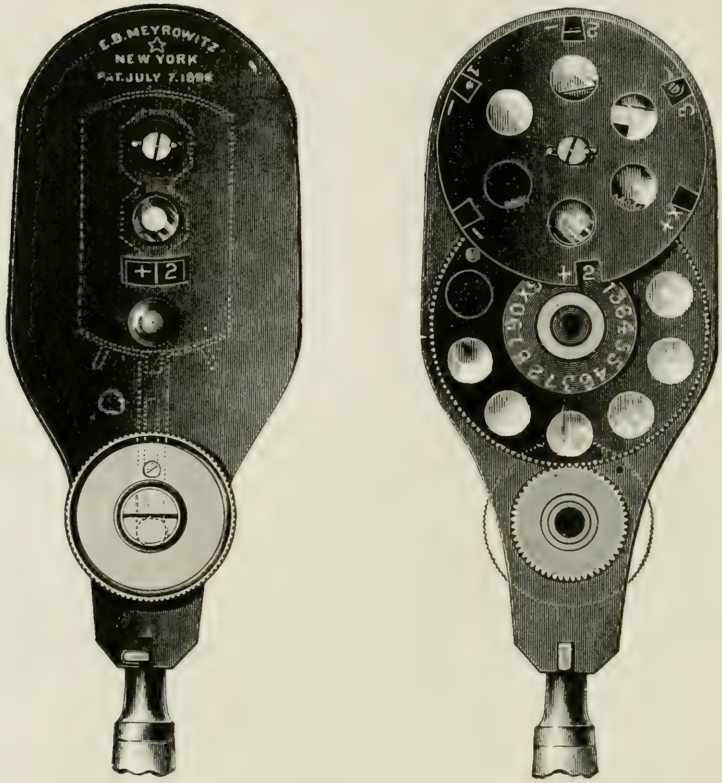
For the purpose of rapidly changing the lenses, the upper disc can be revolved independently by means of two small projecting pins, each turn of the same causing a change of 10 numbers in the series.



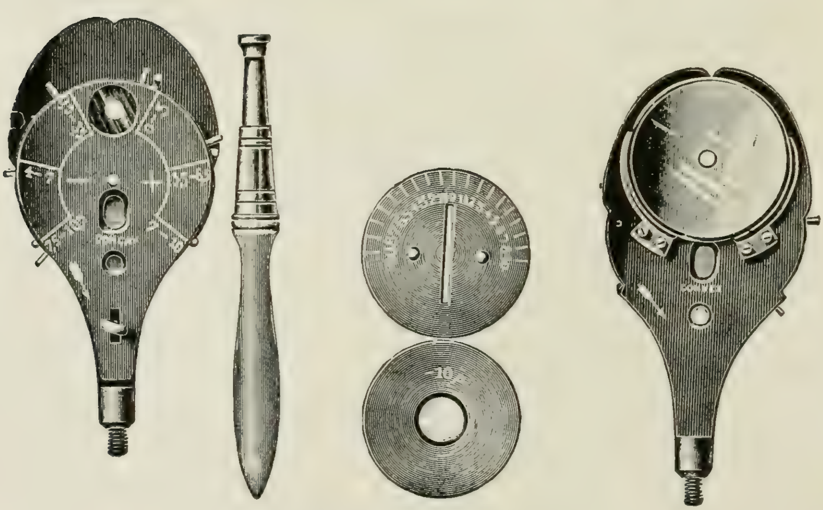
Knapp Ophthalmoscope.

The small driving-wheel that operates the discs is so placed that the finger of the operator is not brought between the ophthalmoscope and the face of the patient. See the cut.

Landolt ophthalmoscope. Two superimposed Rekoss discs are, in this instrument, provided with lenses so that intervals of half a diopter, both concave and convex, can be presented from zero to 10 D. It has both plane and concave mirrors; also such adjustable adjuncts as a stenopaic disc, extra minus 10 D. lens, etc. Compare the illustration.



The Knauer Ophthalmoscope.

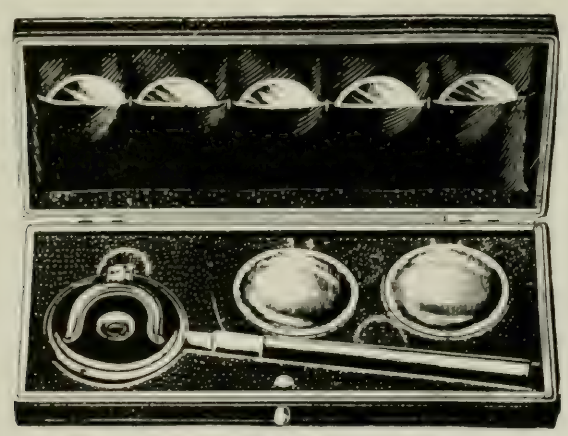


Landolt's Ophthalmoscope.

Laurence ophthalmoscope. This so-called "meniscus" instrument is described in the *Ophthalmic Review*, July, 1864. The inventor first announced his discovery under the title "A new Ophthalmoscope on the 'Ghost' principle" in the *Royal London Ophthalmic Hospital Reports*, IV, 1863. It was one of the earliest of the hand instruments in which a single lens was employed instead of two or three layers of glass.

The Lawford ophthalmoscope is briefly described on p. 4751, Vol. VI of this *Encyclopedia*.

The Liebreich ophthalmoscope is of the early simple type, having two large and five smaller (correcting) lenses; the latter to be fitted into a clip in front of the eye-hole. See the figure.



Liebreich's Ophthalmoscope.

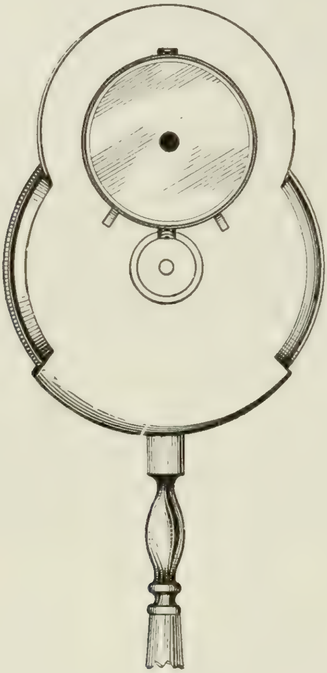
Liebreich's large (stationary) ophthalmoscope was, as in similar instruments of the day, used for the indirect method. It could, however, also be employed in the direct method by means of a special attachment. See Zehender's *Klinische Monatsbl. f. Augenheilk.*, p. 485, 1863.

The Loring ophthalmoscope, already referred to, is so well known and its modifications are so numerous that it seems superfluous to describe the instrument here. However, both the early models and an improvement by De Zeng are depicted herewith.

The former instruments are provided with a (round but later) rectangular tilting mirror and 19 lenses mounted in two discs—a full disc and a quadrant of a disc. The quadrant rotates immediately over the disc and around the same center, and contains 4 lenses, minus .50, minus .16 and plus .50, plus 16. When not in use the quadrant

is beneath its cover, and the instrument then represents a simple ophthalmoscope wth 16 lenses, the series running with an interval of 1. D., and extending from 1. to 7. plus and from 1. to 8 minus. If the higher numbers are desired they are obtained by combination with those of the quadrant, the focus of the combination being shown in the small opening below the sight aperture.

The modified De Zeng instrument (pictured in the text) differs from the old style instrument in that only those numbers represent-

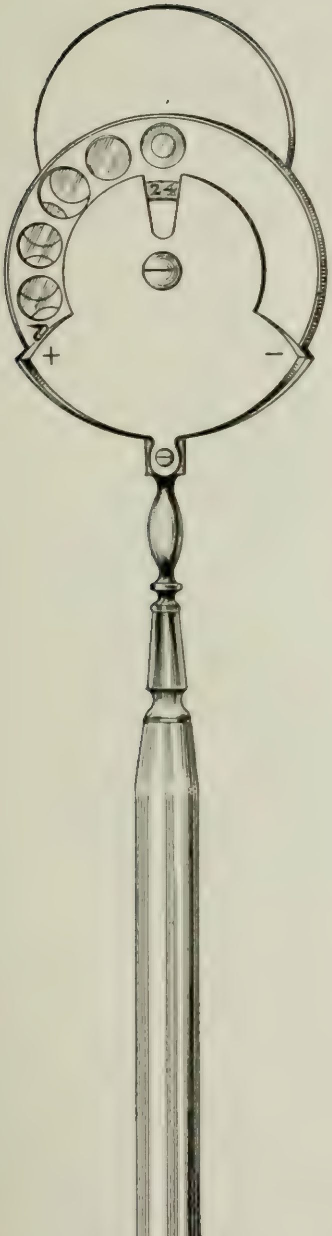


Loring Ophthalmoscope, with Round Mirror.

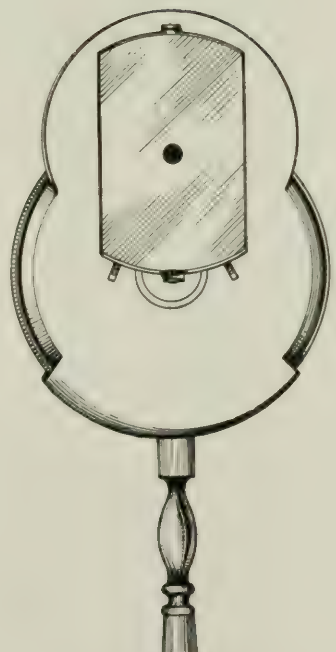
ing the sum total of the lens power, obtained at the sight hole, can appear in any position of the discs. The instrument contains 19 lenses, has a friction mounted tilting mirror, with or without perforation, and is rectangular or round in form. The round mirror gives a superior illumination and answers the purposes of a retinoscope as well as an ophthalmoscope.

Marple ophthalmoscope. See the subsection *Electric ophthalmoscopes;* as well as p. 4230, and p. 4274, Vol. VI, of this *Encyclopedia.*

Marquez (Arch. de Oft., XII, p. 542, 1912) has devised an ophthalmoscope with a plane reflector arranged to give the effect of a con-



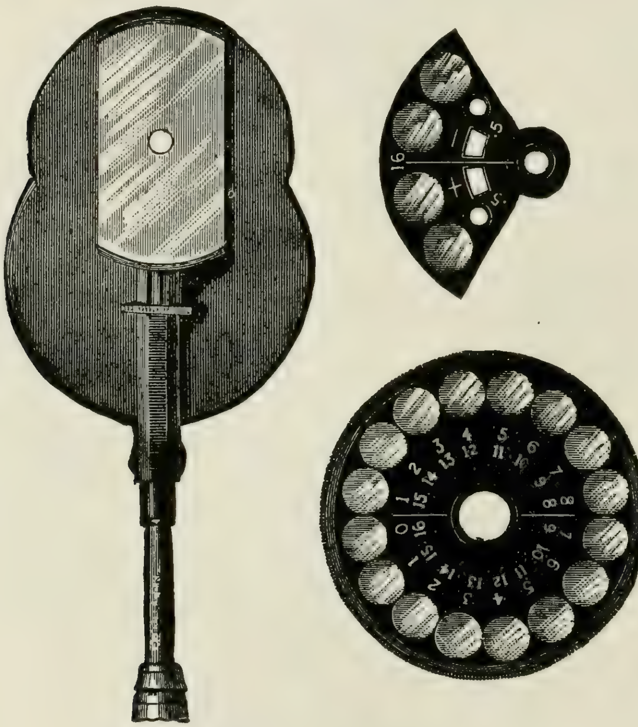
The Loring Complete Ophthalmoscope.



Loring Ophthalmoscope, Modified by De Zeng.

cave mirror, when desired, by placing a + 2 D. lens in front of the mirror.

Mauthner ophthalmoscope. This observer modified the larger Jaeger instrument, which he describes and pictures in his *Lehrbuch der Ophthalmoscopie,* p. 108. The cylindrical portion of the ophthalmoscope contained a slot in which any one of eight lenses could be placed.



Loring Ophthalmoscope.

May ophthalmoscope. In addition to what is said of the electric ophthalmoscope on pp. 4230 and 4274, Vol VI of this *Encyclopedia,* May *(Trans. Amer. Ophthal. Society,* Vol. XIV, Part i, p. 165, 1915), who is among the early inventors of the electrically lighted instruments, claims, among other advantages of his electric ophthalmoscope, that it throws a solid illuminated surface on the fundus of the eye, and that nothing is seen of the lamp filament. This is mainly effected by a solid rod of glass, which acts as a condenser at the lower part and as a reflecting prism at its upper part. May believes that this system of illumination is superior to that now in general use

(reflecting mirror), and that it is free from shadows, reflexes, or lamp-film effects, and that it lights up the fundus much better. By a slight modification, the electric ophthalmoscope can be converted into a transilluminator. A simple form of the instrument is constructed for the use of the general practitioner.

Meyerstein ophthalmoscope. This is one of the earliest "prism" instruments, of the Coccius type, and was first described by the

Student Loring Ophthalmoscope.

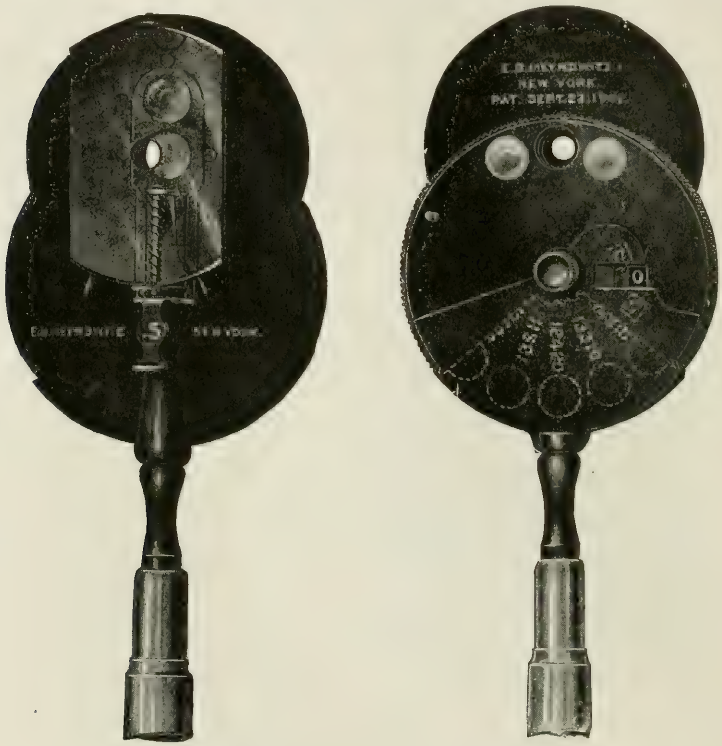
Simple Loring Ophthalmoscope. II.

inventor in his pamphlet on the subject, *Beschreibung eines neuen Augenspiegels,* 1853.

Meyrowitz "automatic" ophthalmoscope. To operate the instrument it is necessary to rotate the main disc. The quadrant lenses are, by an ingenious mechanism, brought automatically into play as soon as the series in the main disc is exhausted, and the actual value of each lens, or combination of lenses, is indicated through a small, square opening, as shown in the cut.

To effect a rapid change of lenses, the quadrant can be moved independently of the lower disc by an easy pressure against the small pin projecting from the quadrant, each resulting combination being accurately shown at the index hole.

There are in all 95 distinct combinations with a regular interval of .50 D. throughout the entire series. See the figure.

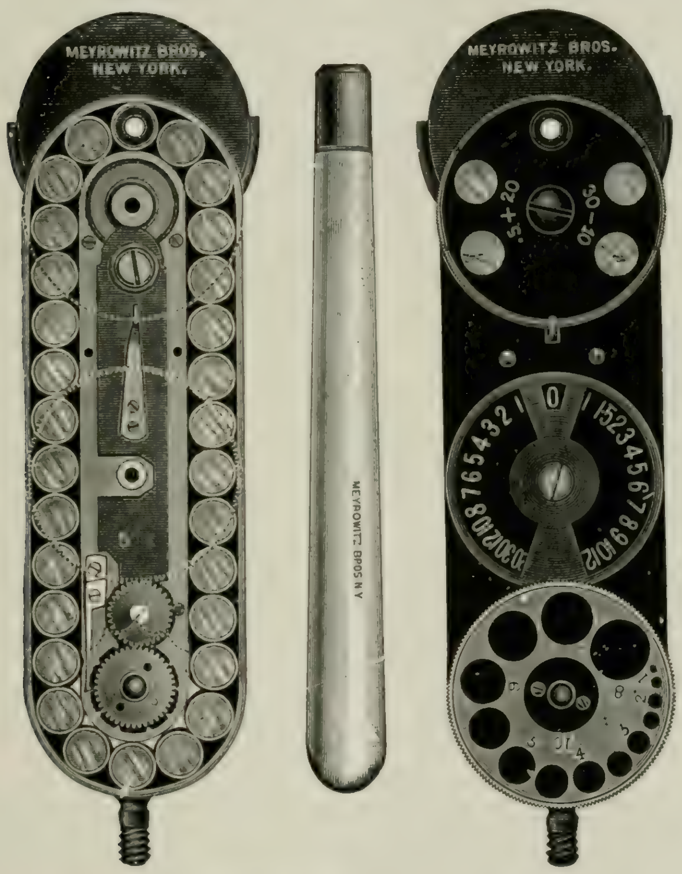


The Meyrowitz "Automatic" Ophthalmoscope.

The Morton ophthalmoscope is as well known in Great Britain as Loring's instrument is in America. The advantages claimed for this ophthalmoscope are, briefly: A continuous chain of single lenses sufficient for all ordinary purposes. The provision of a few separate, easily adjustable lenses for extraordinary cases. The lens in the sight-hole is always shown on the indicating disc (except in the rare cases where one of the extra lenses just mentioned is used). There is only one driving-wheel. Three mirrors revolving on a central pivot, so that either can be at once brought into position. The width of the instrument is only 1¼ inches, while the driving-wheel, being 3 inches

below the sight-hole, is unimpeded in its action by contact with the face of observer or patient. See the figure.

Ohm ophthalmoscope. This instrument, as described by the inventor *(Ophthalmic Year-Book,* p. 21, 1912), is intended for the examination of both eyes at once and to facilitate the study of miners'



The Morton Improved Ophthalmoscope.

nystagmus. It is used by the indirect method. The light from an electric lamp is reflected from the ophthalmoscope mirror, passes through the 10 D. object lens, behind which are placed two mirrors, as shown at *D* in the figure. The pencil of light thus divided is reflected from two other mirrors into the two eyes and illuminates the fundus of each. The emergent rays pass in the opposite direction along the same path, entering the observer's eye from the sight-hole

at *B.* By this instrument Ohm was able to observe simultaneously, two eyes, as shown during ophthalmoscopic examination.

Among the simple, folding, pocket ophthalmoscopes is the instrument of *Oldham,* figured herewith.

The Panas ophthalmoscope furnishes a series of correcting lenses from 1 to 19 D. minus, and from 1 to 20 D. plus. It has, also, three mirrors, plane, concave and inclined. See the illustration.

The Parent ophthalmoscope. This instrument supplies two series of lenses—1 to 20 D. concave and convex. It is provided with a con-

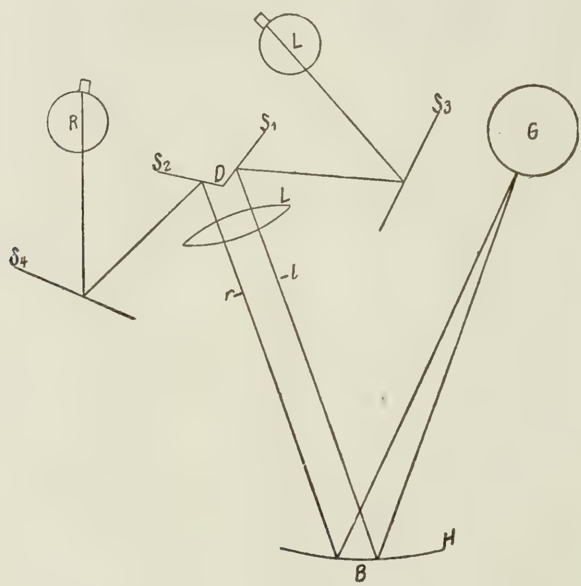
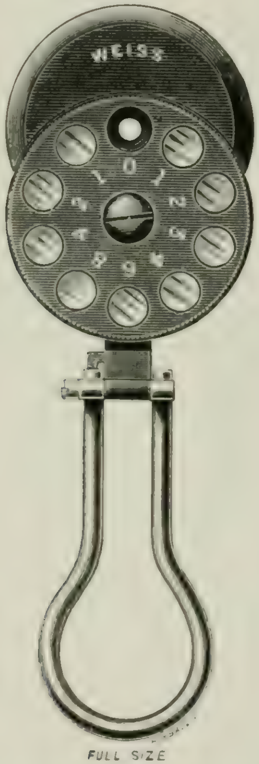


Diagram of the Ohm Bilateral Ophthalmoscope.

cave mirror of 25 cm. focus; also two others (inclined), plane and concave, the latter of 8 cm. focus. By combination a series a cylinders—1 to 7 D.—can be utilized.

The Paxton improved ophthalmoscope consists of a wheel containing 19 lenses, with four extra lenses in segment in front of instrument. It has also the revolving mirror fitting similar to the Morton, with concave mirror and revolving angle mirror for direct examination. This instrument is fitted with a 2-in. condensing lens, metal handle fitted with pupilometer and color test. See the figures. This instrument can be fitted with an extra plane mirror, similar to the Morton. See, also, p. 4751, Vol. VI, of this *Encyclopedia.*

Brown Pusey ophthalmoscope. This instrument was devised to meet the demand for a small, light, compact scope that could be folded and so, conveniently, carried in one's pocket. The instrument primarily sought was one with concave mirror with a hole in the silvering, and an attachment of a + 4 lens, which is a complete ophthalmoscope for ophthalmoscopy by the indirect method. It was found that for the covering of such a mirror, a back carrying a plane mirror would

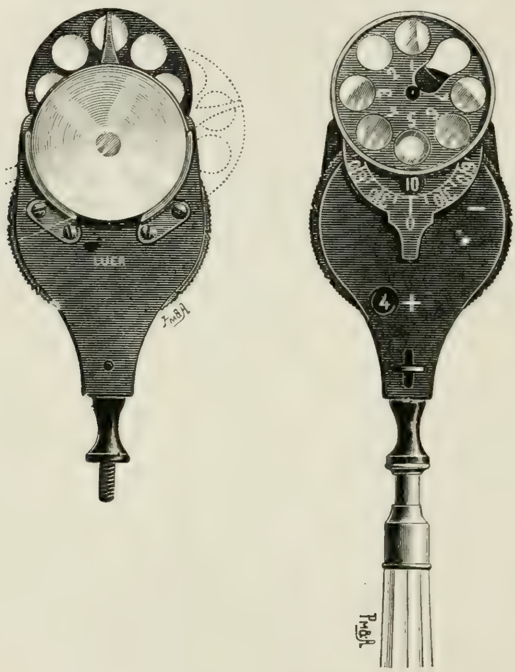


The Oldham Ophthalmoscope.

add very little in weight and cost, and would have the advantage of making it a complete instrument for retinoscopy. At the back of the concave mirror is placed a wheel in which there are five lenses, a + 2, a + 4 for use in the indirect method, a + 8 for use when examining on the levels in front of the retina, a — 3 for the unskilled user, who accommodates when making a direct examination, and a — 10 for examining myopes. There is also one plain hole in the wheel. The instrument is so compact that it weighs less than two

ounces; it is ¼ inch thick, 2⅜ inches long, is solid and has locking joints. See the illustration.

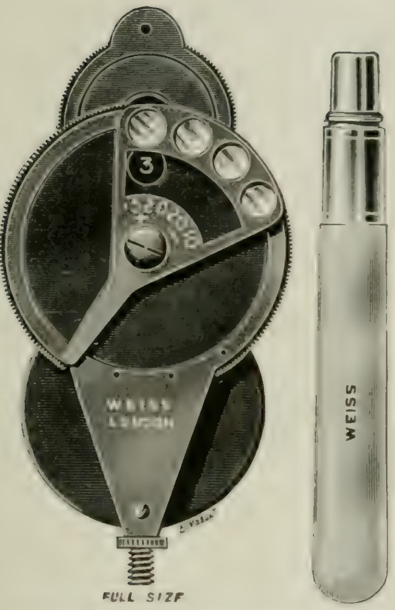
Pyle ophthalmoscope. This instrument, by Walter L. Pyle, a modification of earlier models, presents two superimposed lens-discs, 34 mm. and 37 mm. in diameter respectively, each containing 14 apertures for lenses. Each disc has independent movement. The inner disc—that is, the one nearest to the observer's eye—contains the high-power lenses, both convex and concave. Its circumference



The Parent Ophthalmoscope.

is milled and it is rotated directly by the finger, as in the Loring instrument. The outer disc—that is, the one nearest to the mirror—contains the low-power lenses, both convex and concave. A toothed edge is cut on its circumference, and it is rotated by a lower driving wheel, 17 mm. in diameter. The two discs are inclosed in a metal case with a detachable handle. The lenses are 6 mm. in diameter. They are stopped by a spring, which clicks as each lens is wheeled into place.

The advantages claimed for this instrument are neatness, compactness and durability; avoidance of direct rotation of the disc



Paxton Improved Ophthalmoscope.

The Paxton Improved Ophthalmoscope.

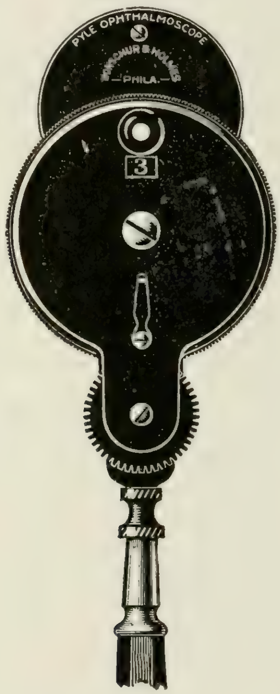
containing the low-power lenses by the finger close to the patient's nose and cheek, as in the Loring instrument; continuous movement and

Brown Pusey Ophthalmoscope.

successive increase of both convex and concave lenses up to 24 D. without removal from the first position before the eye; avoidance of combinations of lenses; continuous registration and single registering

aperture in the case; simplicity. The dimensions of the instrument are $1\frac{1}{2}$ in. wide by $2\frac{1}{4}$ in. long. It can be carried in the vest-pocket. The exact size and shape are shown in the accompanying illustration. There are no points of special wear and tear or of fine adjustment to get out of order.

The Risley refraction ophthalmoscope, which the inventor presented to the American Ophthalmological Society in 1887, is a modification of the Loring instrument. The series of lenses and their arrange-



Pyle Ophthalmoscope.

ment (see the figure) have been preserved, but the stem or metal portion of the handle has been so modified as to contain two series of convex cylinders which can be pushed upward between the mirror and sight hole of the instrument. One of these slides contains + .50 cyl., + 1.00, + 1.50, + 2.00 and + 2.50; the other + .25, + 3.00, + 4.00, + 5.00 and + 6.00 D. These axes are all parallel with the stem of the instrument. By the superposition of the slides, + .25 cyl. intervals can be secured up to + 3.00 D. and + .50 D. intervals up to + 8.00 D. It is obvious that this series of cylinders can be combined with all the convex and concave spherical lenses in the

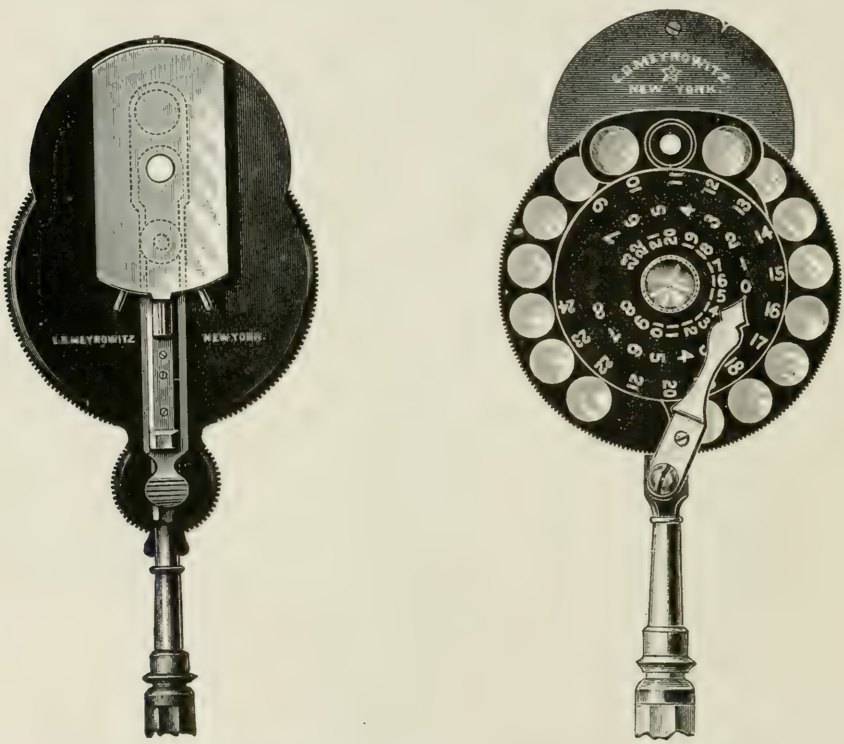
Loring instrument with + .25 cyl. and + .50 cyl. intervals, affording all the possible combinations of the set of trial glasses ordinarily in use. Dr. Risley is now using it in his daily public and private practice, but it is not being manufactured now probably because of

Risley Ophthalmoscope.

its cost. It has never been modified for use as an electric ophthalmoscope although that could be readily done. See the figure.

Roth-Loring ophthalmoscope. Two models of this instrument are on the market. One of these is provided with an automatic quadrant and index, and tilting mirror; the other has in addition a small driving-wheel. See the figures.

In the construction of this ophthalmoscope the general plan and dimensions recommended by Loring have been adhered to, and the object of the improvement is mainly to overcome the difficulty experienced in obtaining and reading the higher combinations, which formerly necessitated the removal of the instrument from the eye to bring the quadrant lenses before the sight-hole, thus interrupting the examination. In this instrument the combination of the higher numbers is effected automatically by a continuous revolution of the



Roth's Improved Ophthalmoscope, with and without Driving Wheel.

disc, which also moves a pointer which indicates upon a dial the number of each lens, or combination of lenses.

In addition to the lenses contained in the disc and quadrant, a + .50 D. lens is mounted in a slide attached to the front of the instrument, directly behind the tilting mirror, in such a manner that it can instantly be brought into combination with any of the lenses contained in the series by an easy and natural movement of the index finger, thus giving a regular interval of .50 D. throughout the entire

series from + .50 D. to + 23.50 D., and from — .50 D. to — 24. D., making in all 95 distinct combinations.

Schnabel ophthalmoscope. This early instrument is of importance if for no other reason that it was first fitted with no less than three Rekoss discs set with lenses and so superimposed and combined as to give the refractive effect of 39 lenses in all.

Schoeler demonstrating ophthalmoscope. This inventor *(Jahresber. d. Augenklinik,* p. 51, 1876) devised his instrument with a minute mirror placed obliquely behind the opening of the ophthalmoscopic mirror. The "demonstration" rays were reflected from the former smaller surface.

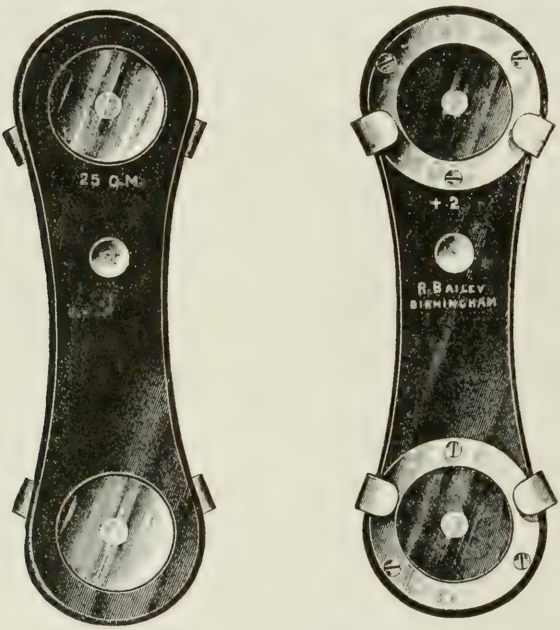
Schweigger ophthalmoscope. This instrument *(Berlin Klin. Wochenschr.,* p. 585, 1871) was one of the early demonstrating ophthalmoscopes, so constructed that the light rays, returning through the opening in the mirror, were in part allowed to proceed to the observer's eye, the remainder being deflected by a prism to the eye of another person to whom the demonstration was made.

Priestley Smith ophthalmoscope. This instrument is described in the *Ophthalmic Review,* p. 33, Feb., 1910. The body or handle is a flat strip of black celluloid, this material being used because it is tough and not brittle. It carries two mirrors, one plane, the other condensing, though not concave. A white, concave, disc inserted in the handle near to the condensing mirror distinguishes it from the other at a glance, or by touch when the instrument is in the hand. Behind each mirror is a socket in which any lens from the ordinary trial case, up to about + or — 10 D., can be placed. The instrument is intended chiefly for the shadow test, for examination of the media, and for the indirect method of examining the fundus. In the consulting room, where the trial case is at hand, it answers well for the direct method also. Elsewhere, at the bedside, for example, it must be supplemented by a few trial lenses if it is to be used for this latter purpose.

The chief novelty of the instrument lies in the construction of the mirrors, which, though not perforated, are free from a disadvantage hitherto inseparable from the non-perforated form. A perforated mirror has the advantage that the sight-aperture cannot become clouded by dust or moisture, but it has the disadvantage that the sides of the tunnel in the glass, however skilfully this may have been bored and blackened, are apt to reflect light into the observer's eye; this drawback is usually minimized by making the mirror extremely thin, but such mirrors are easily broken. A non-perforated mirror has no

tunnel to cause confusing reflection and need not be thin, but, as hitherto made, it presents a difficulty as to cleaning.

In this instrument the back of each mirror is protected by cementing upon it with Canada balsam a disc of glass of the same diameter as the mirror itself, so that the combination forms practically a solid glass disc having a reflecting film of silver embedded in it like a fly in amber. One of the cuts shows a plane mirror protected in this way. A concave mirror, the back of which is of course convex, could be protected in like manner by using a concave instead of a flat pro-



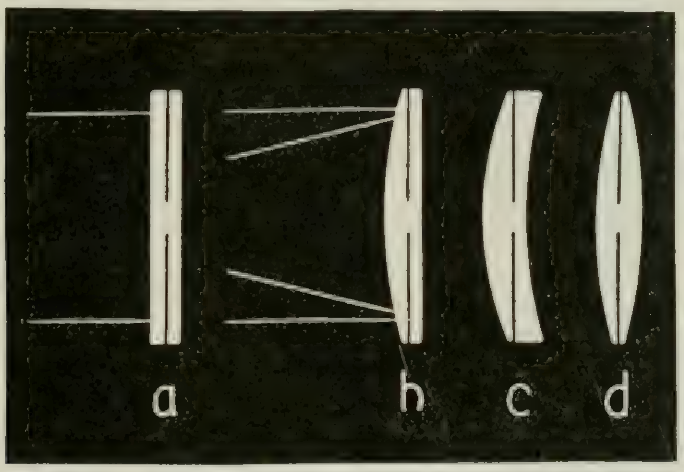
Priestley Smith Ophthalmoscope.

tecting glass, but the desired result is obtainable in a better way. A condensing mirror is not necessarily concave.

If an ordinary bi-convex lens be placed immediately in front of a plane mirror, light reaching the mirror through the lens will be reflected as from a concave mirror, and the power of this compound reflector will be double that of the lens, for the light passes through the lens twice. Applying this principle for the purpose of an ophthalmoscope, we take a plano-convex lens of 2 D. (50 cm. focus), silver the plane surface, blacken the free surface of the silver, remove the coating from a small central area, and cement a flat disc of glass upon it. (See the cuts.) This gives a condensing mirror of 25 cm.

focal length, and when it is used as an ophthalmoscope the observer has a lens of + 2. D. before his eye. The solid combination has an advantage over a perforated concave mirror of equal strength with a supplementary convex lens behind it. In either case there is one thickness of glass before the eye, but the new mirror has no tunnel, is practically unbreakable, and can be wiped as easily as a trial lens. For the presbyope who habitually needs a convex lens behind his mirror for the indirect method, such a permanent combination is very convenient.

The condensing mirror can be made of any desired focal length by using a plano-convex lens of twice that focal length. The effect



Sections of Ophthalmoscope Mirrors. (Priestley Smith.)

a, Plane mirror; b, Condensing mirror with effect of convex lens; c, Condensing mirror with effect of convex lens; d, Condensing mirror with convex back.

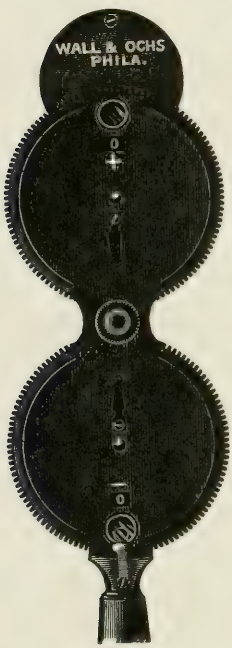
of this lens in relation to the observer's eye can be neutralized, or it can be increased or diminished to any desired extent, by substituting for the flat protecting glass a suitable plano-convex or plano-concave lens. If the observer be ametropic and desire to have a correction of his refraction embodied in the instrument, this can be effected by using a plano-spherical, a plano-cylindrical, or a toric lens, in the same way, though where the two eyes are unequal and both eyes are used in ophthalmoscopic work the same instrument would not be suitable for both.

Stellwag von Carion (Theorie der Augenspiegel, Vienna, 1854) invented an instrument which, although of the earlier type, was well known both during and after its day. It consisted of a concave, per-

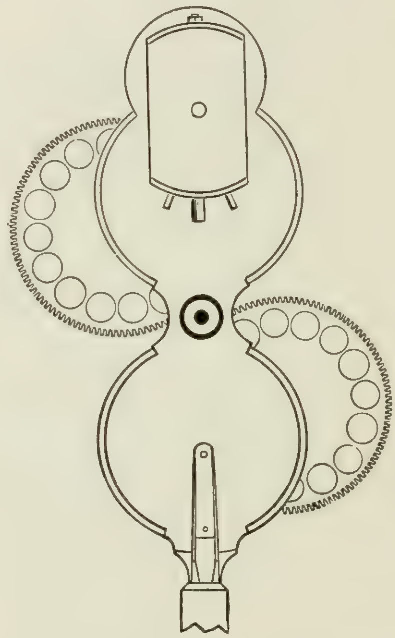
forated mirror fastened to a holder by a ball-and-socket joint. This arrangement permitted the mirror to be placed at any desired angle to the illuminating rays. Behind this mirror a Rekoss disc was placed, containing four convex and three concave lenses. The instrument was compact, convenient and easily carried about.

Tanner bimanual ophthalmoscope. See p. 4752, Vol. VI, of this *Encyclopedia.*

Thorington ophthalmoscope. This scope is made of two milled-edge discs, connected by a small cogged wheel. The latter is riveted



Thornington Ophthalmoscope. I.



Thornington Ophthalmoscope. II.

to the shaft. Each disc has a vacant opening and fifteen spheres, one disc with minus and the other with plus spheres numbered from one to fifteen diopters. The operator can easily change the disc of minus lenses to the disc of plus lenses by pushing with his thumb against the edge of the lower or upper disc when it will revolve into place before the sight-hole. The mirror is concave with short radius of curvature and the sight-hole not cut through the glass but made by removing the quicksilver. Compare the illustrations.

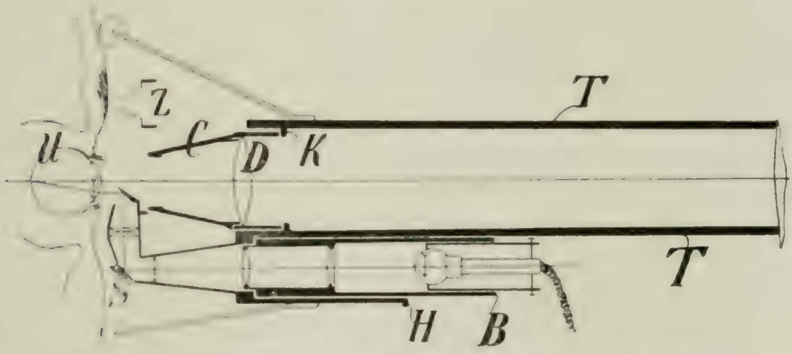
This instrument has three advantages over the other varieties, in that the higher power lenses are at hand and there is no lens super-

imposed to get the higher power. The operator's hand never touches the patient's face or nose in making an examination, as the handle of the instrument is well downward.

The mirror by its unique sight-hole avoids the reflection which frequently obtains when the sight-hole is made by cutting the hole through the glass.

Thorner's demonstration ophthalmoscope. Although useful for teaching purposes demonstration ophthalmoscopes (see p. 3814, Vol. V, of this *Encyclopedia*) have not been generally adopted for clinical purposes.

The Todd ophthalmoscope. M. H. Todd (*Journ. Am. Med. Assocn.*, July 19, 1913) describes a simple and inexpensive electric attachment for the ordinary ophthalmoscope that renders the latter of greater use in ward work or when the patient is lying down.



Reflexless Ophthalmoscope of Wolff, as Applied to the Patient.

Ulrich ophthalmoscope. This is one of the earliest instruments in which a prism was used, the most efficient of which was the Coccius ophthalmoscope (q. v.). It is described under the caption *Beschreibung eines neuen Augenspiegels*, in Henle and Pfeuffer's *Zeitschrift für rationelle Medicin*, 1853.

Wadsworth ophthalmoscope. The principal difference between this comparatively early instrument and other contemporary ophthalmoscopes lies in the first use of the well-known, tilting mirror, that still bears the Wadsworth name.

Wolff claims for his *reflexless ophthalmoscope* (*Ophthalmic Year-Book*, p. 19, 1913) the advantages of a clinical instrument for ordinary use as well as in stereoscopic ophthalmoscopic photography, and as a demonstration instrument. As shown in the figure, it consists of a large tube *T* to which are attached rests that steady it by press-

ing upon the margins of the orbit above and below the eye. In this tube the convex lens *D* is mounted so that it can slide to or from the observed eye sufficiently to bring the principal focus to the plane of the pupil, its motion being limited by *K*. Extraneous light is shut out by the cone *C*, which can be extended by the screen *Z* for monocular ophthalmoscopy. The illuminating apparatus *B* is placed in a tube which slides in *H*. It consists of an incandescent lamp and condensing lenses with a plane mirror *S*, by which the rays are reflected upward upon the prism that in turn reflects them into the lower part of the pupil.

In general size and shape, Wolff's instrument resembles the ophthalmofundoscope of Baum.

Zehender ophthalmoscope. This observer (*Arch. für Ophthalm.*, Vol. I, pt. 1, p. 121, 1854) used a convex mirror with a convex spherical glass attached, in the same manner as in the instrument of Coccius.

The Ziegler ophthalmoscope. The inventor (*Trans. Am. Oph. Soc.*, 1914) describes his instrument as consisting of two discs, one containing a series of plus lenses and the other of minus lenses, which are symmetrically superimposed, assembled as a unit, and mounted in a dust-proof case. Both discs have individual gears and are interlocked with a central bevel, thus permitting the plus and minus numbers to appear on the same plane and to be read through the same opening, which includes the peep aperture.

A small meshed wheel drives the plus disc while the minus disc is milled and exposed through an opening in each lower quadrant of the case, thus permitting direct manipulation.

The lenses are held by metallic fastenings and mounted with a — 16 D. lens on the plus disc and a + 16 D. lens on the minus disc, which arrangement trebles the series of lenses from thirteen to thirty-nine when the proper numbers are superimposed. In this way a total of seventy-eight distinct combinations can be made, which is fourteen more than the ophthalmoscope of Loring will yield. The correct reading is obtained by adding or subtracting the two sets of numbers exposed. The lower or plus disc contains 0, + .50, + 1, + 2, + 3, + 4, + 5, + 6, + 7, + 8, + 10, + 12, + 14 and — 16 D. The upper or minus disc contains 0, — .50, — 1, — 2, — 3, — 4, — 5, — 6, — 7, — 8, — 10, — 12, — 14 and + 16 D. This brings 16 D. and 0 next to each other and by crossing gives a range of from 0 to 30 D., with half diopter intervals up to 8 D., with 1 D. intervals up to 24 D., and with 2 D. intervals up to 30 D. The following serial numbers can be obtained in both plus and minus lenses: 0, .50, 1, 1.50, 2, 2.50, 3, 3.50,

4, 4.50, 5, 5.50, 6, 6.50, 7, 7.50, 8, 9, 9.50, 10, 11, 11.50, 12, 13, 13.50, 14, 15, 16, 16.50, 17, 18, 19, 20, 21, 22, 23, 24, 26, 28, 30.

Instead of the usual quadrilateral mirror, 20x30 mm., a round tilting mirror has been attached, having a diameter of 22 mm., an aperture of 2 mm., and a curvature of — 1.50 D. A small friction pivot is also provided to prevent undue tilting of the mirror. This mirror is omitted when the electric light attachment is used.

The chief advantages claimed for this model are: Separate discs for plus and minus lenses; the numbers of both discs showing on the same plane; the large series of lenses, 78 in all, ranging from 0 to 30 D.; the ability to turn at once from 0 to + 16 D.; the ease of manipulation, because the driving wheels are set low enough to avoid the eyebrow.

Ziegler also describes an attachment by which the instrument may employ the electric light illumination. It is joined to the ophthalmoscope as a unit, and is made interchangeable for (*a*) magazine battery, (*b*) accessory handle, cords and pocket battery, or (*c*) street current properly controlled. The magazine battery handle is made compact to avoid bulk, and marketed in two sizes, the smaller type of Crampton handle being more handy but less efficient and the larger type being more awkward to manipulate but having about four times longer life. The inventor prefers the smaller type solely for its greater convenience. The handle, cords and pocket battery are sometimes better adapted for bedside use. The battery case is made of metal, knurled and finished in a permanent black. The special rheostat is located on the top of the magazine, and connected to the *positive pole*, in order to avoid accidental lighting of the lamp and rapid exhaustion of the battery whenever the battery handle is inadvertently *laid on a metal surface*. This fault is present in the majority of ophthalmoscopes that are joined to magazine bodies. To avoid annoying reflexes the tube which carries the condensing lens, the U-shaped mirror of Marple, and the tungsten lamp, is specially treated and blackened inside. The sliding friction joint permits proper adjustment of the lamp filament vertical to the slot in the mirror. A similar adjustment can be made by rotating the lamp alone. If the lamp gives a reflex this may be reduced by *frosting the tip*, but the illumination will also be reduced. A small spring contact socket is located in the tip of the adjustable or focusing slide, which maintains the connection even if the lamp should become unscrewed a few turns, and thus prevents flickering of the lamp while the instrument is in use. A second spring contact is located in the peripheral end of the focusing slide, and a third spring contact is placed in the acces-

sory handle to preserve uniform contact between the ophthalmoscope and the handle. The corrugated outer collar of the focusing slide is made much smaller than in most instruments and can easily be manipulated with one finger. The U-shaped mirror of Marple has been made of polished metal and beveled to a very thin edge. It is, therefore, both non-breakable and interchangeable. It has a focal strength of —1 D. and yields a clear image free from penumbra. It is absolutely non-corrodable. Two small metal caps or tubes are provided to slip over the naked lamp after removing the ophthalmoscopic head, the larger one (a) for transillumination of the globe or sinuses, and the smaller one (b) for the Wernicke pupillary inaction test. A separate retinoscopic head, containing a plane mirror and an extra lamp, can be adjusted to either form of electrical attachment.

Ophthalmoscopic. Ophthalmoscopical. Of, or pertaining to, the ophthalmoscope or its use.

Ophthalmoscopist. One versed in the use of the ophthalmoscope.

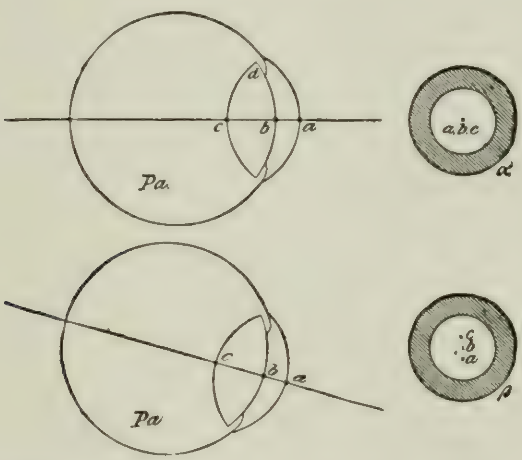
Ophthalmoscopy. The science and art of examining with the ophthalmoscope the interior of the eye. This section should, of course, be read in conjunction with such headings as **Ophthalmoscope**; as well as **Ophthalmoscopy, Medical,** and **Comparative ophthalmology**. See, in particular, p. 4760, Vol. VI, of this *Encyclopedia*.

The size of the ophthalmoscopic image varies with the conditions under which the methods are employed, and with the refraction of the two eyes. The magnification of the details of an emmetropic eye examined by direct ophthalmoscopy is about seventeen times that of normal. In hypermetropia it is less; in myopia it is greater. A plane mirror gives a larger, but less brightly illuminated, image than the concave one.

Uses of the ophthalmoscope. The ophthalmoscope is used: (1) to detect opacities in the dioptric media, (2) to study the fundus, (3) to determine the refraction, and (4) to demonstrate differences of level in the fundus.

To detect opacities the concave mirror of the ophthalmoscope is used. The opacity appears as a dark cloud or black spot on the red background. Any spot appearing black by this method of examination looks white or gray by oblique illumination, for this reason:—rays of light from the fundus, falling on an opacity from behind, are returned unseen by the surgeon; and, in oblique illumination, rays of light striking an opacity from in front do not reach the retina, but are reflected into the eye of the examiner. To locate an opacity it should be remembered that opacities in the cornea and lens are immovable, while vitreous opacities are generally floating, but in rare

instances may be fixed. Hence, after moving the eye, vitreous opacities float, while corneal and lenticular ones are stationary. In many cases an opacity can be localized by oblique illumination. To distinguish between an opacity in the cornea and one in the anterior or posterior part of the lens, it is often necessary to use parallactic displacement. This can be understood by reference to the figure, in which the points *a*, *b*, and *c*, represent, respectively, opacities in the cornea, anterior and posterior parts of the lens. If the surgeon looks at the eye in the direction of the optic axis, he sees only one opacity, as shown in the upper figure. If, however, the patient looks downward, all of the opacities are seen, that of the posterior part of the



Localization of Opacities in the Lens and Cornea. (Fick.)

lens being highest, that of the anterior part of the lens in the middle, and the corneal opacity lowest. An apparent movement upward when the eye is actually turned downward proves that the opacity is behind the plane of the iris; an apparent movement in the same direction as the actual movement of the eye shows the opacity to be located in front of the plane of the pupil. If the patient's eye is held still and the surgeon moves, the opposite is true, opacities in front of the pupil seemingly moving in the opposite direction, while those behind the iris move in the same direction. Finally, any opacity which is found is to be inspected at close range by using a strong convex lens behind the ophthalmoscope. Besides its use in finding opacities, the ophthalmoscope readily detects a tear in the iris or the existence of a partial dislocation of the lens.

Examination of the fundus. This process will shortly be described, but it may be said here that the surgeon, seated as depicted for the *indirect method,* illuminates the pupil with light reflected from the mirror, interposes the convex glass in the path of luminous rays, and searches for the head of the optic nerve. The lens must be held squarely in front of the eye; otherwise the fundus will appear distorted. To find the optic disc, in examining the right eye, the patient should look in the direction of the surgeon's right ear. After studying the disc for pathologic changes the vessels, the macula, and the peripheral parts of the retina are passed in review. The fundus is next to be examined minutely by the direct method. Inability to see the details of the fundus clearly will suggest the presence of an error of refraction too great for the accommodation to overcome.

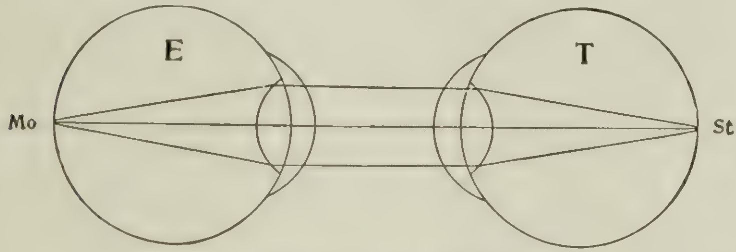
The ophthalmoscope as a refractometer. Used as a refractometer, the ophthalmoscope is employed for two purposes: to determine the nature of an error of refraction and its amount. The former is accomplished by holding the mirror at from 30 to 50 centimetres from the eye to be examined. The surgeon illuminates the eye, looks through the mirror, and seeks for vessels. If any are seen, the eye is ametropic. To determine the nature of the error the surgeon has only to move his head from side to side and watch the movement of the vessels. If they move apparently in the same direction as the surgeon's movements, the eye is hypermetropic; if opposite, it is hypometropic (myopic).

In the hands of experts the ophthalmoscope can be used to determine the amount of refraction errors. Either the direct or indirect method may be employed, although the former is preferred as the simpler procedure. In the remarks that follow reference will be made alone to the direct method. In order to measure refraction with the ophthalmoscope, several conditions must be complied with:—

1. The accommodation of both patient and surgeon must be relaxed.
2. A particular part of the fundus must be selected to be refracted.
3. The surgeon must be emmetropic; if ametropic, his error must be corrected.
4. The surgeon should approach as closely as possible to the eye to be refracted.
5. The findings of the ophthalmoscope must be confirmed by other tests before the surgeon prescribes for the patient.

In explanation of these rules it is necessary to state that the accommodation of the patient is usually relaxed by the use of a cycloplegic or by having him look at a distant object, while the art of holding his

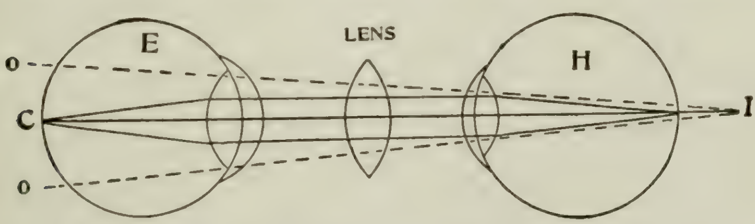
own accommodation in abeyance comes to the surgeon after long practice. In selecting a part of the fundus to be refracted, it is customary to choose either the optic disc or, preferably, one of the vessels at the temporal side of the disc near the macula. The surgeon should approach a point 13 millimetres in front of the cornea, this being the anterior focal point of the eye. If a greater distance is



Ophthalmoscopy in Emmetropia.
The eye of the examiner, *E*, and of the patient, *T*, are normal in refraction.

chosen, it will be necessary to subtract the distance from the glass to the cornea from the lens selected to correct hypermetropia, and add it to the correction for hypometropia (myopia).

In case an emmetropic eye examines another eye which is emmetropic, the image will appear clear and distinct, because rays coming from the normal eye are parallel. In the accompanying figure the examiner, *E*, looks into the emmetropic eye of the patient, *T*;



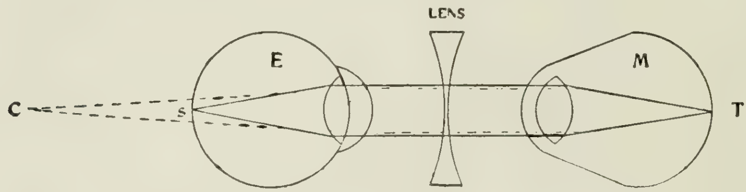
Measurement of Hypermetropia by Direct Ophthalmoscopy.

and a clear image of *St* will be formed at *Mo* on the retina of the examiner. If, however, the surgeon does not obtain a clear image of the fundus, it will be in order for him to place a convex glass behind the mirror.

If this improves the picture of the fundus, the surgeon increases the strength of the glass until he obtains the strongest convex lens through which the details of the fundus can be obtained. This glass is the measure of the patient's hypermetropia. Ophthalmoscopy under

these conditions is explained by the next figure, in which rays coming from the retina of the hypermetropic eye, *H*, appear as if coming from a more remote point, *I*, behind the eye. The convex lens renders the divergent rays parallel, and they are brought to a focus at *C* on the retina of the examiner.

If the surgeon finds that his view of the fundus is made more dim by the convex glass, he should move the disc and place a concave lens behind the mirror. The weakest concave glass with which the details of the fundus can be recognized is the measure of the patient's hypometropia (myopia). Possibly the surgeon will be able still to see the fundus through a glass 1 or 2 D. stronger; but he does so only by calling his accommodation into play. Rays emerging from the myopic eye are so convergent that they would meet at the punctum remotum, *C*. The concave lens renders them parallel, and they fall on the emmetropic eye of the surgeon to form a focus at *s*.



Measurement of Myopia by Direct Ophthalmoscopy.

The application of ophthalmoscopy to astigmatism comprises, first, the diagnosis of astigmatism, and, second, its measurement. For these purposes the direct method is preferred. If the surgeon examines an astigmatic eye, he will observe that the picture is blurred in parts; when vessels running vertically are in focus, those taking a horizontal course are blurred, and vice versa. Much stress is laid upon the shape of the optic disc as characteristic of astigmatism, the round disc of the normal eye being seen apparently oval in astigmatism. It is unwise, however, to depend on this. A better criterion is that afforded by the ability of the surgeon to see all parts of the disc clearly at the same time. In astigmatism this will be impossible; when the temporal and nasal sides of the disc are clear, the upper and lower borders are out of focus in the astigmatic eye. The differences produced in the retinal picture by irregularity of curvature of the lens or cornea will enable the surgeon to measure the defect by direct use of the ophthalmoscope. The retinal vessels are taken as the objective points in the examination. It is to be remembered that horizontal lines or vessels are seen through the vertical meridian of the cornea

and vertical lines or vessels are seen through the horizontal meridian. Remembrance of this simplifies the problem which, in truth, is the measurement of the hypermetropia or hypometropia (myopia) of each of the principal meridians, the difference between these findings constituting the astigmatism. If, for example, the surgeon sees the vertical vessels clearly with a weak concave lens (2 D.) and the horizontal vessels are clear only after the interposition of a convex glass of 4 D., it follows that the case is one of mixed astigmatism (myopia of 2 D. in the horizontal and hypermetropia of 4 D. in the vertical meridian). If the horizontal vessels are clear without any glass, and the vertical ones are seen best with a convex 1 D., there is simple hypermetropic astigmatism of 1 D. Should the vessels in one principal meridian be clear

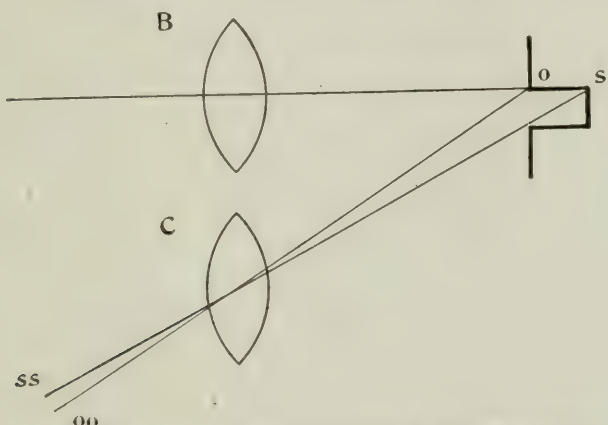


Diagram to Show Parallactic Displacement in Indirect Ophthalmoscopy.

only with a + 2 D. lens and those in the other principal meridian require a + 3 D. glass, the case is one of compound hypermetropic astigmatism. In the estimation of refraction by ophthalmoscopy the measure of error is the weakest concave lens and the strongest convex one which renders the vessels clear.

In conclusion it must be said that the estimation of refraction by the ophthalmoscope is unreliable, except in the hands of a few experts, and that in all cases the findings by this method should be confirmed by retinoscopy, keratometry, and the use of the trial-case.

The determination of differences of level in the fundus, which is of practical value in the swelling of the nerve-head occurring in optic neuritis and its excavation in glaucoma, may be accomplished in one of two ways: by the phenomenon of parallax or by the measurement of the refraction of two points occupying different elevations. Paral-

lactic displacement is produced by moving the convex lens in indirect ophthalmoscopy. By shifting the lens it is noticed that two observed parts of the fundus image move at unequal rates in case a difference of level exists. Thus, in a glaucomatous excavation, the vessels climbing over the edge of the optic disc will move faster and in front of those in the bottom of the cup. In case a projection of the nerve-head occurs, as in papillitis and in intra-ocular tumor, the same phenomenon will be observed. Appreciation of parallactic displacement may be facilitated by study of the accompanying figure. Here a glaucomatous excavation of the nerve-head reaches from *o* to *s*. When the convex glass is placed at *B*, the points *o* to *s* are in line, and the idea of depth does not obtain, since one point covers the other. If, however, the lens is displaced to *C*, it will be observed that the image of the point *o* is reproduced at *oo* and that of *s* is likewise reproduced at *ss;* and the points seem to have separated, *o* moving more rapidly than *s*.

In order to measure elevations and depressions of the fundus by ophthalmoscopy it is necessary to proceed as in the measurement of errors of refraction: the glass is found which brings the depth of an excavation into focus and then it is ascertained what glass will clear the image of the parts normally situated. The difference expressed in dioptres and multiplied by 0.3 will give the depth of the excavation in millimetres. For example, let it be supposed that, in a case of glaucomatous cupping, the depth of the excavation is in focus with a — 5 D. glass, and the margin of the disc and adjacent retina are best seen with + 1 D., a difference of 6 D. The depth of the excavation is 1.8 millimetres. In the same manner a swelling of the nerve-head can be measured.—(J. M. B.)

The methods of using the modern ophthalmoscope. As the chief purpose of an ophthalmoscopic examination is to see as much as possible of the interior of the eye under observation it is desirable to dilate the pupil;—in the case of mammals this is accomplished by instilling into the eye atropin, homatropin, euphthalmin or some other mydriatic.

Before the invention of the self-luminous or electric ophthalmoscope the source of illumination of the ocular interior was a gas jet or electric bulb—preferably an argand lamp—stationed in a darkened room, and placed on a level with the eye to the side of the head.

In examinations of the human eye the observer sits opposite the individual whose ocular interior is to be explored, and placing the mirror close to his own eye and about 40 or 50 cm. from the eye to be examined reflects the light upon the latter, while he looks at it through the small opening in the ophthalmoscopic mirror. In very short-sighted and very long-sighted eyes, but not in normal ones, the

vessels of the retina, the entrance of the optic nerve, etc., can be more or less distinctly seen.

The details of the retina, choroid, etc., can be seen in two different ways. In the indirect method, as applied to man and most other ver-

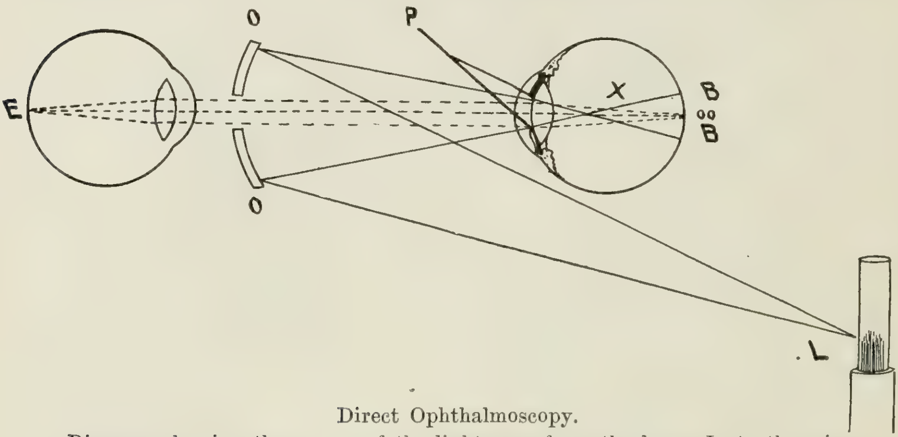
Relative Positions of Examiner and Examined in Indirect Ophthalmoscopy.

Relative Position of Observer and Observed in Direct Ophthalmoscopy.

tebrates, the observer, seated as shown in the cut, holds a strong (16 D.) convex lens about 10 cm. from the eye under examination, and between it and his own, when a clear real image of part of the

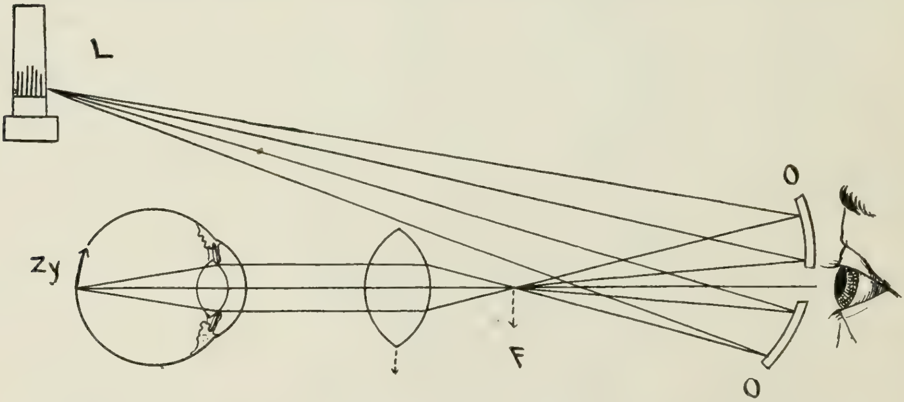
fundus, inverted and magnified about four diameters, appears in the red light of the pupil.

In the direct method (see the figure) the observing eye must be placed as close to the observed as the intervention of the mirror will



Direct Ophthalmoscopy.

Diagram showing the course of the light rays from the lamp, L, to the mirror, OO, whence they are reflected directly upon the observed retina at BooB. Thence they are reflected through the opening in the mirror, OO, to the observer's eye at E.



Indirect Ophthalmoscopy.

Diagram showing the course of the light rays from the lamp, L, to the ophthalmoscopic mirror, OO, whence they are reflected to a focus, at F, where they diverge, to be once more focused by the lens on to the retina at Zy, to be finally reflected to the eye of the observer at the opening in the centre of the mirror, OO.

allow, when a virtual image of a still smaller part of the fundus is seen, but erect and magnified about fourteen diameters.

Direct ophthalmoscopy, or the examination by the upright or erect image, is illustrated by means of the figure. A side lamp (L) is used,

the rays from which are focused by the perforated mirror of the ophthalmoscope (OO) and thrown into the observed eye through the dilated pupil (P). The rays of this pencil now cross about X and impinge on the retina and choroid at OO and cover the ocular background from B to B. Thence a sufficient number of efferent rays are reflected and refracted back through the ocular media of both the observing and observed eyes to the percipient elements of the former, at L.

Another illustration shows indirect ophthalmoscopy, or, as it is sometimes called, the examination by the inverted image. A divergent light pencil proceeds from the lamp, L, to the ophthalmoscopic mirror, OO, which focuses the rays at F. These subsequently divergent rays are now made parallel by the convex lens and are thus brought to a focus on the retina-choroid by the dioptric apparatus of the observed eye. Thence the reflected and emergent rays follow the same path and come to a focus, at X, in the eye of the examiner, who will see an inverted aërial image of the observed fundus.

By means of the electric self-illuminating ophthalmoscope one is enabled not only to dispense with the cumbersome side light but to make satisfactory examinations of the fundus oculi in only partially-darkened surroundings—serious considerations in doing field and hospital ward work.

The fact that a considerable portion of the light thrown into the interior of the eye through the pupil is reflected by the structures of the background into the eye of the observer is the principle of the ophthalmoscope. Moreover, this reflection, or rather refraction, of the incident rays, modified by the character of the media through which they pass furnish the wonderfully varied and colored pictures observed in the ocular background.

According to Contino (*Clinica Oculistica,* May-June, 1914) the *size of the inverted image* varies with three facts; the power of the lens used, the state of accommodation of the observed eye, and the static refraction of the same. For example, a 9 D. or 10 D. lens gives a more satisfactory inverted image than the 13 D. or 14 D. which is commonly provided. Contino gives a series of tables showing the size of the image in varying degrees of error; he does not show, however, a point which was brought out thoroughly and clearly in a monograph by Bjerrum, viz.: the varying size of the image in ametropic eyes when the distance of the lens varies. In emmetropia, the size does not vary, in myopia the size, which is always smaller than in emmetropia, increases as the distance of the lens increases. In hypermetropia the

image is larger than normal and decreases as the distance of the lens increases.

Contino shows that the alteration of size varies with the form of error; thus an axial myopia of 5 D. will not give the same sized image as a myopia of curvature of the same degree.

Contino advises, so as to secure a uniform size for the inverted image, that we should employ lenses of different strength, weaker for myopia, stronger for hypermetropia.

Ginestous reports that in experiments in ophthalmoscópy by the the use of lights of various colors the most valuable colors are red and green. The red while rendering hemorrhages less conspicuous, emphasizes black; the green minimizes the pigment changes, and renders the red of hemorrhages more marked.

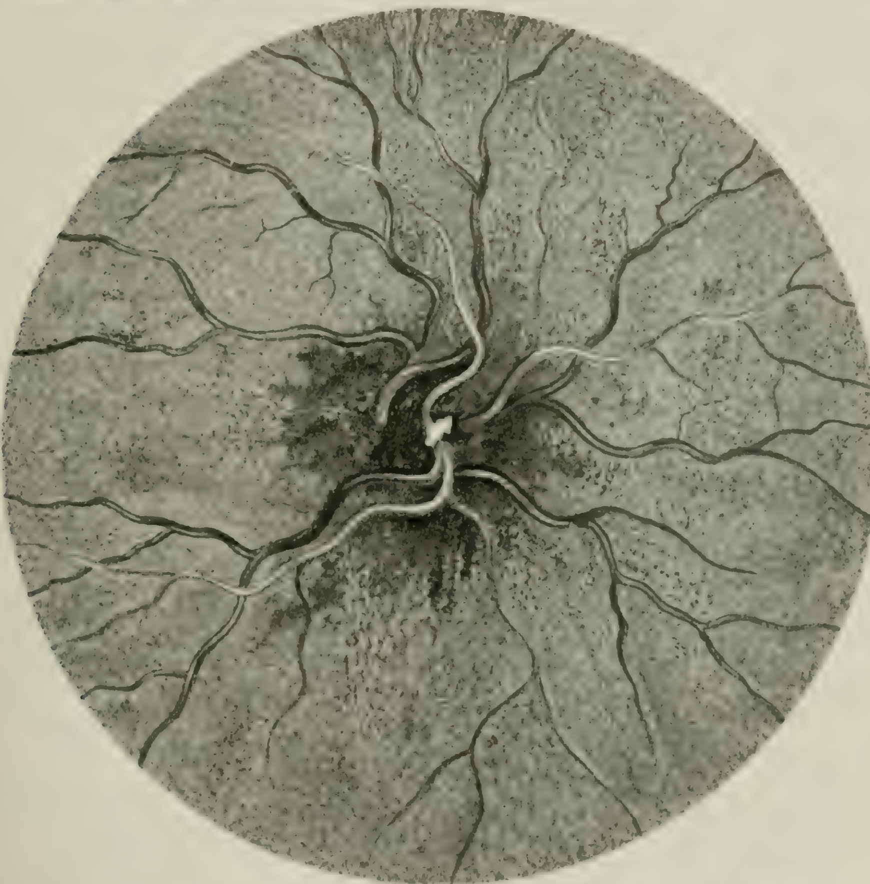
Mosso calls attention to the advantage gained when examining the fundus by the direct method, if the light be thrown a little to the side of the lesion looked at. The diffused light from tissues behind it tends to emphasize slight changes in appearance. This observation was first made by Haab.

Of the special application of ophthalmoscopy to a study of the ocular interior—treated under individual captions—it is desirable here to draw attention to only one—the *ophthalmoscopic study of the iridic angle.* This subject has been especially discussed by Salzmann (*Zeitschr. für Augenheilk.*, Jan., 1914). If the patient be made to face in a direction at right angles to the observer's line of vision, the iridic angle can, under certain circumstances, be examined by indirect ophthalmoscopy. The observer must be at a greater distance than is usual in ordinary indirect ophthalmoscopy of the fundus, the lens must be held farther away, and must be slightly tilted toward the astigmatism present at the extreme periphery of the cornea. It is rather difficult to find the exact position of the lens which gives the best picture.

When the anterior chamber is deep and the cornea large, it is easy to make the examination described, myopic and buphthalmic eyes being the most favorable for the purpose. If the anterior chamber be abnormally shallow, the use of a contact glass is advised.

The *drawing and painting of fundus pictures* requires an unusual artistic and professional equipment. The successful depiction of the varied tints and other peculiarities in individual cases—both normal and abnormal—requires that the painter wield not only a facile brush but a ready ophthalmoscope—he should be not merely an accomplished artist but he ought also to be a well-equipped ophthalmoscopist. Few men—or women—have possessed these accomplishments, but among

the more moderns may be mentioned the late Miss Margaret Washington (q. v.) of Philadelphia and Mr. A. W. Head of London, illustrator of Lindsay Johnson's *Atlas of Mammalian Fundi* and Casey Wood's *Fundus Oculi of Birds*, as well as of numerous other fundus paintings of human eyes. The older artists, beginning with E. Jaeger and Liebreichs, are mentioned under their proper captions.



Goldenburg's Case of Anomalous Nerve Head with Good Vision.

Ophthalmoscopy, Medical. The appearances of the fundus oculi in health and in general diseases have already been largely described and depicted in many sections and captions of this *Encyclopedia*.

An account of the *normal fundus* is given under **Fundus oculi** on p. 5315, Vol. VII; while a description of the ophthalmoscope and of ophthalmoscopic methods will be found under **Ophthalmoscopy**, as

well as under **Ophthalmoscope**; **Helmholtz**, and on p. 4748, Vol. VI of the *Encyclopedia*. Generally speaking, also, the eyeground views are considered in the description given of every systemic disease in which fundal changes occur. The reader is consequently referred, in addition to those about to be mentioned, to such captions as **Tuberculosis of the eye**; **Syphilis of the eye**; **Congenital anomalies**; **Nephritis, Ocular symptoms of**; **Choked disk**; **Cerebrospinal meningitis**; **Choroiditis in general**; **Retinitis in general**; **Optic nerve, Diseases of the**; **Macula, Diseases of the**; etc.

Among additional captions of interest to students of this section that have already appeared in this *Encyclopedia* are: **Amaurotic family idiocy,** Vol. I, p. 287; **Amblyopia from hemorrhages,** Vol. I, p. 292; **Amblyopia, Toxic,** Vol. I, p. 303; **Arteriosclerosis, Ocular,** Vol. I, p. 614; **Albuminuric retinitis,** Vol. I, pp. 207-212; **Basedow's disease,** Vol. II, p. 901; **Brain tumors,** Vol. II, p. 1273; **Bright's disease,** Vol. II, p. 1296; **Diabetes insipidus,** Vol. V, p. 3922; **Diabetes mellitus,** Vol. V, p. 3924; **Disseminated sclerosis,** Vol. VI, p. 4041.

Anomalous fundi with normal vision. Several writers—among them Parsons, Sattler, Neeper, Beard—have described cases in which well-marked fundus conditions simulating even serious organic disease of the optic nerve and retinal tissues, have been shown to be in a sense normal, or at least have been unaccompanied by defective eyesight. Michael Goldenburg (*Archives of Ophthalmoscopy,* XLIV, No. 3, 1915), for example, depicts anomalous nerve heads, with good vision. In one case he found the attempt to locate the disk as a preliminary step to a more detailed examination to be apparently futile. Tracing the vessels from the periphery to the point of convergence did not seem to help in locating anything that might resemble the disk. However, at the point where the vessels apparently come together and where the nerve head should be (see the accompanying cut) there was a very small, intensely white spot that appeared with the ophthalmoscope about the width of an artery and in lenght about two or three times that dimension, with its long axis directed to about two o'clock. The exact nature of this spot it was impossible to define. The vessels appeared negative in every respect. The retina was normal, with the exception of a marked pigmentation which was very intense in the region of the nerve head, but gradually assumed a lighter shade toward the periphery; no evidence of the nerve head or disk margins being present.

OPHTHALMOSCOPIC FINDINGS IN DISEASES OF THE BLOOD AND OF THE CIRCULATORY SYSTEM

Hyperemia. Pathological dilatation of the blood-vessels in the eye is usually the result of inflammation. Active hyperemia from increased force of the circulation is of frequent occurrence. Neither Dyer nor Green found intraocular hemorrhages in subjects after hanging. In sudden diminution of the intraocular tension, due to passive hyperemia, hemorrhages may occur, i. e., after operations for cataract and glaucoma. Chronic passive hyperemia is not frequently observed. Knapp reports a case of enormously distended veins of the retina without valvular disease, but with general dilatation and hypertrophy of the blood-vessel system of the body.

Anemia. In local anemia of the retina the condition may be confined to the arteries, while the veins may be hyperemic. This is true in glaucoma, in new-formations, and in inflammatory products, the cause being pressure upon the central artery and vein. Intraocular tension may also produce local anemia, i. e., ischemia of the retina. During attacks of migraine and irritation of the cervical sympathetics, a narrowing of the retinal vessels has been observed. Acute anemia after extensive or repeated hemorrhages, after the use of certain drugs and in association with certain diseases will be described under their sub-titles.

The anemic fundus is a physical consequence of the pathologic condition of the blood and presents a typical ophthalmoscopic picture. It may occur in all kinds of intense anemia, but is most marked in aplastic anemia of small children. Salzmann (*Zeitschr. f. Augenheilk.*, Jan. 29, 1913) describes the fundus in five cases.

A child, aged 11, suffering from pernicious anemia with one-half of the normal amount of hemoglobin, exhibited the first and most important symptom of the anemic fundus, the translucent column of blood. The vessels were much lighter on the disc than on the fundus, the reflex stripe was scarcely visible on the disc and the sharp border of the disc shone through the vessels. The disc was somewhat paler, the fundus of normal red coloration.

In the second case, a girl, aged 12, with congenital hereditary splenomegaly and chronic anemia, the percentage of hemoglobin was only 34. The blood column was translucent and very light, especially in the veins, so that the difference of color between veins and arteries was diminished. The disc was not pale, but the fundus was yellowish and peculiarly granulated.

This third characteristic sign, the granulation of the fundus, was

still more marked in a girl, aged 1½, with hemoglobin of from 17 to 24 per cent., and light hair. The vesels on the disc appeared as pale reddish bands without reflex stripes, the disc was pinkish, not white or grey, but the physiologic differences between nasal and temporal portions were lacking. The yellowish color and granulation of the fundus were very marked.

All these phenomena were much more pronounced in the fourth case, a girl, aged 1½, with a plastic anemia, only 16 per cent. hemoglobin, and brown hair. The disc was very pale, but not entirely devoid of the reddish hue. The vessels were so indistinct that the grouping of the main branches at the hilus could not be recognized in the inverted image. At the fundus only the largest vessels were visible. The veins were wider, and quite tortuous at the periphery. The fundus was yellow and granulated.

Salzmann ascribes the granulation to the unequal pigmentation of the single pigment epithelia, just as in the normal eye. That it is so clearly visible in anemia must be due to the fact that the underlying choroid is unusually pale. He reached this conclusion from the fifth case, a child aged 4, with anemia and hemolytic icterus, with 40 per cent. hemoglobin. On admission the yellowish color and granulation were very marked. But after the anemia was very much improved, in a month, the fundus had the aspect of a light blond individual, viz., distinctly visible choroidal vessels with light interstices, and the granulation was not more intense than ordinary. What is seen in the very anemic fundus is, so to speak, the pigment epithelium, whereas in the normal eye the red of the underlying choroid is added. Here the granulation becomes less distinct by the diminished contrast between the lighter and darker cells, because the fundus in general is more intensely colored.

Other fundus changes in anemia—such as pulsation, alterations of caliber of the vessels, swelling of the disc, opacities and extravasations in the retina—are complications to produce which, besdes, anemia, other disturbances are necessary, e. g., of heart action, vascular walls, etc.

Loss of blood. The ophthalmoscopic examination made soon after a hemorrhage, whether it be from the alimentary canal, uterus, venesection, nose, lung, wounds or urethra, shows blurring of the disc, edema of the retina, diminishing towards the periphery. At times a few hemorrhages and small white spots may be seen in the retina. In unfavorable cases optic atrophy follows, and occasionally retrobulbar neuritis. See, also, Vol. I, p. 292, of this *Encyclopedia*.

As an example of *optic atrophy following uterine hemorrhage,*

Calhoun (*Ophthalmic Record,* Vol. XIII, p. 383, 1913) reports the following case: F. E., æt. 38, one week after her regular menstruation had a profuse hemorrhage from the uterus. Patient collapsed and became unconscious and was ill in bed for a week. Ten days later noticed that she was unable to see anything in the room. Pupils normal, reacted to light and convergence. Both optic nerves were pale, retinal vessels were contracted, causing a general anemia. Fields showed a partial hemianopia. The pathological change which takes place in the eyes, following such hemorrhages, appears to be due to a degeneration of the ganglionic cells of the retina, from an interference with their nutrition.

An instance of *blindness after gastro-intestinal hemorrhages* is given by G. H. Grout (*Arch. of Ophth.,* Vol. XLIII, p. 235), J. M., æt. 66, after several gastro-intestinal pains, vomited blood, which continued intermittently for three days, with the presence of blood in stools. Amount lost, several (?) pints. Vision, O. D. 3/200; O. S. 15/200. Ophthalmoscope revealed diffuse pallor of discs and blocking of small retinal arteries.

Pernicious anemia. Biermer was the first to demonstrate retinal hemorrhages in pernicious anemia, which one may regard as a usual complication of the disease. They may occur in all parts of the fundus and at different levels of the retina, but they are mostly flame-shaped and superficial. The center of the hemorrhagic area is often paler than the edge, so that whitish spots with a red ring around them are very characteristic. The edges of the disc may be blurred and the papilla is usually pale and the vessels small. See, also, Vol. I, p. 420, of this *Encyclopedia.*

Secondary anemias. The anemias from carcinoma of the stomach may be associated with hemorrhages into the retina. Retinal hemorrhages in cases of severe burns are probably due to changes in the blood. Similar conditions may be induced by loss of blood from intestinal parasites, especially the *Ankylostomum duodenale* (q. v.) and the *Bothriocephalus latus.*

Anemia and chlorosis. Rehlmann, in eighty-six cases of general anemia, found definite retinal anemia in 26 per cent., and marked dilatation of the vessels in 60 per cent. Schmall found the vessels pale and narrow in 80 per cent. of all chlorotics he examined. Pulsation of the arteries is common. Retinal hemorrhages have been described in this condition but it is of doubtful occurrence in simple anemia. Optic neuritis and neuro-retinitis have been frequently recorded, but such a diagnosis must be accepted with reserve. See, also, Vol. I, p. 420, of this *Encyclopedia.*

W. C. Posey (*Arch. of Ophthal.*, Vol. XXXVIII, p. 473) reports a case of chlorosis in a woman, æt. 21, whose fundus showed an intense neuro-retinitis with marked edema of the retina. Veins were distended, arteries smaller. No hemorrhages or extravasation into retina. Vision, O. D., counting of fingers at one foot; O. S., 6/12. The fields in both eyes were concentrically contracted, with a large absolute scotoma, up and out, in the right eye. Blood count showed hemoglobin 65 per cent.; erythrocytes 4.710.000; leucocytes 9.600. See Vol. III, p. 2068, of this *Encyclopedia.*

Scurvy, purpura and hemophilia. Hemorrhages into the retina may occur in any of these diseases; also neuro-retinitis and choked disc have been reported. See p. 5796, Vol. VIII of this *Encyclopedia.*

Leukemia or leucocythemia. Ophthalmoscopic examination of the fundus often reveals an orange-colored reflex; the veins are dilated and tortuous, often with white lines along them, and are bright-red, not dark in color. The arteries are small and pale, yellowish-red. The retina is often hazy and edematous, the disc pale, seldom swollen. Retinal hemorrhages and small white spots are common. Schirmer found retinitis in one case out of five leukemic patients. The retinal changes usually appear between the equator and the ora serrata, so that these changes may be present and be overlooked by a casual examiner. Microscopic study of the eyes affected showed an excess of leucocytes in all the tissues and especially along the walls of the retinal vessels.

Chronic cyanosis with polycythemia. Parker and Slocum (*Annals of Ophthalmology,* Vol. VII, p. 473, Jan., 1911) report a case in which the blood examination showed red cells to be 6.500.000 to 7.500.000; in another, from 8 to 9.000.000. The hemoglobin content was respectively 100 per cent. and 110 per cent. Vision was somewhat reduced. The eye changes in both cases were similar. Disc margins blurred; edema about the papilla; great tortuosity of the retinal vessels, especially the veins, which were very dark in color, with a few small retinal hemorrhages.

W. B. Weidler (*Trans. Ophthal. Sect. N. Y. Acad. Med.*, Dec. 20, 1915; *Arch. of Ophth.*, Vol. XLV, No. 3, p. 280) reports a case of *patulous foramen ovale.* The patient, æt. 9, at time of birth was described as a "blue baby." At the present time she shows a great amount of purplish-blue discoloration of the lips, tongue, and all mucous membranes that can be examined, and the finger nails have a bluish discoloration. The child usually has cold hands and feet, and is unable to play or endure a slight amount of exertion without undue fatigue and exhaustion. In the eye-grounds the veins and arteries are tremendously enlarged and tortuous and abnormally dark in color,

the calibre being about double that usually seen. The retina is extremely granular and gives a bluish-red reflex, an appearance seen only in extreme cyanosis. Vision is normal. See, also, p. 3607, Vol. V, of this *Encyclopedia*.

Diseases of the aorta, the carotid arteries and the ophthalmic artery. Becker observed a case of aneurism of the ascending branch of the aorta in which there was no trace of a spontaneous arterial or venous pulse present. Haab reported two cases of aneurism of the ascending aorta with no pulsations and only slight dilation of the retinal arteries.

When aneurismal dilations of the carotids are present on both sides the ocular disturbances are more striking. Marked deterioration of vision, decided fullness of the retinal veins, with scattered areas of opacity in the retina have been observed. Michel has seen choked discs in carotid degeneration, these conditions, he thought, interrupting the flow of lymph from the lymph spaces of the optic nerve towards the brain.

Owing to its extreme rarity, true aneurism of the ophthalmic artery plays an unimportant part in fundus changes, although it may produce the same symptoms as the previously described affections.

Circulatory phenomena in the eye in diseases of the heart. Diseases of the heart, especially valvular affections, frequently induce alterations in the circulation of the blood within the eye, but, as a rule, it is difficult to see these changes distinctly and for that reason they are of but slight value in general practice.

In aortic insufficiency one may observe pulsation of the retinal artery some distance from the papilla. Pulsation of the veins is sometimes found to be more pronounced than it is in the arteries in this disease. See p. 5719, Vol. VIII, of this *Encyclopedia*.

Embolism and thrombosis of the central artery of the retina. In these affections there is a pronounced anemia of the retina; not so pronounced, however, as that following that rare lesion, laceration of the central artery, from forcible separation of the optic nerve from the globe.

There is a marked anemia of the retina about the disc and the macula. The vessels form narrow red lines whose ramifications become increasingly finer until they disappear. In many cases the arteries in the vicinity of the disc appear as bright, white streaks. The veins are narrower than normal near the disc but towards the periphery, on the contrary, their diameter is greater. There is an absence of any pulsation. An intermittent flow of blood in the arteries cannot be induced by pressure upon the eye-ball. The most rapid

onset of the opalescence of the retina is in that area which possesses the greatest thickness, viz., in the vicinity of the macula lutea and the zones that surround the papilla. Thus we have the formation in the middle of the fovea centralis of a deep red, ill-defined spot, spoken of as the "cherry-red spot." In the region of the macula the finer vessels are unusually dark and prominent.

Senile angiosclerosis. There are well-marked angiosclerotic and phlebosclerotic changes noted in the aged. This is particularly true of angio-senile sclerosis seen as thickening of the retinal walls and the narrowing of the blood-columns. Later we may see the grey or white streaks that bound the lumina of the blood columns, or even cover it in places. These white changes in the vessel walls in arteriosclerosis are not of frequent occurrence in simple senile sclerosis; indeed, when observed, a suspicion of albuminuria or syphilis must arise.

Irregularity in the calibre of the arteries and veins is seen not rarely in old people. Irregular, knotty-like, or spindle-shaped configuration of the vessels is occasionally seen in the veins, and may even be so marked as to be spoken of as varicose degenerations. Often a single, spindle or sacculate, localized relaxation of the vessel walls, as the result of circumscribed sclerosis, is present.

Whatever may be the significance of new-vessel formation in *senile angiosclerosis,* it is well recognized as a product of inflammation, and usually occurs wthin the anterior portion of the retina.

Hemorrhages under the conjunctiva, in the retina, in the vitreous chamber, and rarely between the vitreous humor and the retina, or between the retina and the choroid, are frequently the result of the senile disease.

Local constriction of the branches of the veins, where they are crossed by arteries, occasionally presents itself ophthalmoscopically. There is usually a marked proliferation of the intima at the crossing points. According to observers, a pulse appears in the veins in angiosclerosis more frequently than it does in the arteries.

Just as phlebosclerosis may produce varicose formations, so does arteriosclerosis play an important part in the formation of aneurisms in the retina.

Finally, we may see partial or complete atrophy of the optic nerve due to pressure of an atheroma of the ophthalmic or carotid arteries, or from aneurismal dilation of the vessels at the base of the brain.

At the present time the prevailing opinion is that *syphilitic diseases of the vessels* are so irregular in their fundus manifestations that their existence very often can only be deduced by the presence of con-

comitant syphilitic lesions. The signs of luetic vascular disease affecting the eyegrounds are: 1. Visible opacity of the walls of the arteries, but rarely of the veins; white lines along the vessel walls; or there may be localized greyish-white opacities. 2. As in senile sclerosis, there may be a narrowing of the blood columns. Hemorrhages and extravasations may take place in the areas affected by the endarteritis. 3. The alterations may show by an irregular filling of the vessel. 4. Groups of circumscribed white splotches, as seen in albuminuria, more rarely occur. 5. The macula is often affected by hemorrhages or pigmentation, as in hereditary syphilis. 6. Slight optic neuritis has often been described. 7. In senile sclerosis, new-vessel formation, as a rule, assumes only moderate proportions, while in syphilis it is more frequent and more extensive. The new vessels are seen after hemorrhages into the retina or vitreous. See, in addition, pp. 612 and 614, Vol. I, of this *Encyclopedia*.

II. OPHTHALMOSCOPIC CHANGES IN DISEASES OF THE NERVOUS SYSTEM

In addition to the following matter the reader is referred to the various **Cerebral** headings in Vol. III of this *Encyclopedia*, as well as to **Brain** captions, and to **Neurology of the eye**. See, also, **Choked disk.**

Focal diseases of the brain. These may be classed under two heads; first, those which cause and increase intracranial pressure, and, second, those which have not that effect. Those of the first class are tumors, including syphilitic and tubercular growths, aneurisms, parasitic and simple cysts and abscess.

Those of the second class are chiefly hemorrhages and softening. In cerebral tumors there are certain symptoms which do not belong to other brain diseases. They are the general or diffuse symptoms, which indicate the presence of intracranial tumor, but nothing more. The three most important symptoms are the double optic neuritis or papilledema, headache, nausea and vomiting; and there may be at times vertigo, drowsiness and attacks of temporary total loss of sight.

In hemorrhages there is not the continuous high pressure usual with cerebral tumor, or else, should be hemorrhage be large enough to cause increased intracranial pressure, it produces a fatal result before optic neuritis develops.

The ophthalmoscopic examination shows the following evidence of inflammation or pressure; the color of the papilla is white, grey or reddish, and is often mottled with white spots or with extravasations of blood. The outlines of the papilla are blurred and appear to be

of a greater diameter than normal. The arteries are thinner, while the veins are distended; the latter become greatly engorged and tortuous, especially at the edge of the swollen optic nerve.

The optic nerve is swollen and projected above the level of the retina and the amount of this swelling may be calculated with the ophthalmoscope by determining the level of a vessel on the retina and then observing the level of the same vessel, if possible, on the surface of the elevated papilla; the difference between these two levels will give the degree of swelling in diopters; three diopters are equal to 1 mm. of elevation.

The neuritis or papilledema generally runs a chronic course and may be replaced by signs of atrophy. The disc then grows paler, its outlines become clearly visible and the vessels upon the disc and retina are narrowed. Optic neuritis is often the first, or one of the first, symptoms of cerebral tumor. It is rare to find it in one eye but it is often somewhat more marked in one eye than in the other. See, also, **Military surgery of the eye,** as well as **Choked disk.**

Disseminated sclerosis of the brain and spinal cord; multiple sclerosis; insular sclerosis. The ophthalmoscopic appearances in this disease may be absolutely normal, or there may be simple discoloration of the whole surface of the optic papilla. Often the temporal part of the disc is atrophic, as it is in the toxic amblyopias. Rarely is there complete atrophy of the disc. In about five per cent of the cases optic neuritis is found. Hemianopsia has never been observed and it would therefore seem as if the atrophic changes were entirely limited to the optic nerve. The optic nerves are affected more often (half the cases) in this disease than in tabes, more often, indeed, than in any other disease of the nervous system except cerebral tumor. See, also, p. 4041, Vol. VI., of this *Encyclopedia.*

Gordon (*Arch. of Int. Med.,* June, 1909) reports fifty-six cases of multiple sclerosis with optic nerve changes. There was well-marked optic atrophy in eleven; retro-bulbar neuritis in seven. He finds that central vision is generally preserved.

In *combined sclerosis of the posterior and lateral columns of the cord* simple progressive optic atrophy, having all the features of a tabetic atrophy, may occur.

Diffuse sclerosis of the brain. Gowers and Bramwell state that occasionally symptoms similar to those of intracranial tumor are seen in this disease. They found optic neuritis when there was no coarse lesion of the brain, but only sclerosis, atrophy, or microscopic lesions have been found post-mortem.

Pseudo-bulbar paralysis of cerebral origin. Eye-symptoms in this

condition are not common but several cases of optic atrophy and optic neuritis have been reported.

General paralysis of the insane. Atrophy of the optic disc occurs in comparatively few cases. In one thousand three hundred and eighty-six patients Gudden found it sixty-five times. Uhthoff found atrophy in nine per cent. of cases examined by him. Klein and Uhthoff describe a more or less intense opacity of the optic disc and retina, which is sometimes accompanied by dilatation of the vessels.

Acute hemorrhagic encephalitis. This disease has been looked upon as an abortive form of cerebro-spinal-meningitis. In three cass Oppenheim observed an optic neurits.

Hydrocephalus. In congenital hydrocephalus, or in the hydrocephalus which appears in early infancy, congestion of the papilla and neuritic atrophy are sometimes seen. In the acquired hydrocephalus of later life, optic neuritis, or congestion of the papilla passing over to optic atrophy, is the rule. Bitemporal hemanopsia has also been reported. Cases of continuous dropping of watery fluid from the nose (nasal hydrorrhea), with blindness due to optic neuritis or optic atrophy, have been published. See p. 6086, Vol. III, of this *Encyclopedia.*

Uhthoff has collected 46 cases of choked disc in hydrocephalus, a sign much less frequent in the hydrocephalus of children, owing to the compensatory expansion of the skull under the increased intracranial pressure. The same observer found primary optic atrophy in thirty-eight cases. See, also, p. 6076, Vol. VIII, of this *Encyclopedia.*

Infantile paralysis. In a child six and a half years old, Sachs saw papillitis, blindness, left ptosis, sixth nerve paralysis, right corneal anesthesia, and right spastic hemiplegia with a hemorrhagic cyst in the left temporosphenoidal lobe which pressed on the left crus cerebri. See p. 6193, Vol. VIII, of this *Encyclopedia.*

Amaurotic family idiocy. A full description, including observations of the fundus changes in this disease, is given on p. 287, Vol. I, and p. 5866, Vol. VIII, of this *Encyclopedia.*

The optic discs in the early stages are healthy. The characteristic fundus lesion lies in the region of the macula lutea of each eye, where this is seen a large white area, tolerably diffuse, with softened edges, which covers a space about twice the size of the optic papilla. At its center is a brownish-red, fairly circular spot, contrasting strongly with the white patch surrounding it. At a later period, with complete amaurosis, there is atrophy of the optic nerve.

Encephalopathia saturnina. In cases with acute cerebral disturbances (convulsion, delirium or coma) there is often optic neuritis,

in which the swelling is considerable and accompanied by hemorrhages. The neuritis may pass off under treatment without impairment of sight, or atrophy may come on. See, also, **Toxic amblyopia.**

Epilepsy. The ophthalmoscope sometimes reveals a marked pallor of the optic disc and contraction of the blood-vessels; or there is a hyperemia of the papilla with engorgement of the retinal vessels. Optic neuritis and optic atrophy have been noted, but these are to be regarded as complications which have nothing to do with the epilepsy. See p. 4484, Vol. VI, of this *Encyclopedia.*

Chorea. See p. 2119, Vol. III, of this *Encyclopedia.*

Deformities of the skull, such as oxycephaly, scaphocephaly, leptocephaly and trigonocephaly. Associated with certain congenital or acquired deformities of the skull optic neuritis as well as post-neuritic optic atrophy, is seen. The ophthalmoscope reveals the presence of optic neuritis, which is sometimes of the choked-disc type, or of post-neuritic atrophy, more or less advanced. This neuritis is sometimes caused by the meningitis whereas Michel thought it might be caused, or at least promoted, by compression of the optic nerve in the optic foramen, which is sometimes abnormally small in these skulls. Hirschberg found optic nerve changes in cases of oxycephaly but never in the scaphocephaly. See **Oxycephaly**; as well as **Tower skull.**

The *simple microcephalic skull* is also liable to be complicated with amaurosis due to atrophic changes in the optic nerve.

Meningitis. Meningitis in its various forms, both of the base and of the convexity of the brain, is apt to be associated with optic neuritis.

In *acute tubercular meningitis* there are found, in from 15 to 70 per cent. of the cases, miliary tubercles in the choroid. These tubercles appear as round, slightly elevated, pale-yellowish spots, with undefined edges, varying in size from 0.5 to 2.5 millimeters, situated in the neighborhood of the optic nerve and the macula lutea. It has been found on examination, after death, that many more tubercles are present than were discovered during life. See 2159, Vol. III, of this *Encyclopedia.*

Miliary tubercles in the choroid also appear in cases of *general, acute miliary tuberculosis* when meningitis is not present.

Optic neuritis is more commonly present in this than in any other form of meningitis.

Both in the sporadic and in the epidemic forms of *cerebrospinal meningitis* eye-symptoms of various kinds are extremely common. Retinitis and plastic irido-choroiditis with purulent infiltrations of

the vitreous, which may at times go on to panophthalmitis, is often seen. Ophthalmoscopic examination may, however, reveal optic neuritis or neuro-retinitis or perhaps only congestion of the optic disc and engorgement of the retinal veins. The optic neuritis of this disease is liable to end in atrophy of the nerve.

Traumatic meningitis, due to falls and blows on the head, without fracture of the skull, is sometimes followed by optic neuritis, which may lead to optic atrophy. In some cases of hemorrhagic pachymeningitis, also, optic neuritis or congestion of the papilla has been seen.

Optic neuritis is rare in uncomplicated *otitic, purulent meningitis* but typical choked disc is probably always an expresson of grave intracranial complications in, e. g., mastoid disease (cerebral abscess, sub-dural abscess, sinus thrombosis, etc.). See, also, p. 1974, Vol. III, of this *Encyclopedia.*

Dementia præcox. Tyson and Clark (*Arch. of Ophthal.,* Vol. XLI, No. 3, p. 223) present, in their report of one hundred and fifteen examples of dementia præcox, one hundred and nine cases examined ophthalmoscopically. Of this group fifty-five were males and fifty-four females. This study included all the different forms of dementia præcox, embracing those who had used alcohol and tobacco moderately or to excess, as well as total abstainers. They classified the fundus changes in the order of their occurrence, as follows: 1. Congestion of the optic discs; hyperemia and edema of the retina; dilated, dark-colored veins; slightly contracted arteries and blurring of the edges of the discs, all in varying degree. These changes constitute practically a low grade perineuritis of the optic nerve. 2. Congestion of the nasal side, with temporal pallor of the discs; dilated veins, contracted arteries. 3. Pallor of the discs; dilated veins; contracted arteries. These changes constitute anemia and partial atrophy of the optic nerve. See, also, p. 3811, Vol. V., of this *Encyclopedia.*

Acromegaly. The ocular symptoms, when present, are quite definite and characteristic. The most frequent signs are defects in the visual fields, usually a bi-temporal hemianopsia. One rarely or never sees the papilledema or papillitis so often present in other forms of brain lesion where tumor is present.

The nerve head shows little or no swelling, perhaps some slight blurring of the edges, with a slightly increased tortuosity of the vessels. Later on, when there is a marked reduction of the field, there may be slight pallor of the discs, but one may see a marked contraction of the field (and the vision reduced to the counting of fingers or to light perception) with but slight changes in the nerve-head. This has been explained by Walker, who believes that the atrophy in the tracts

considerably antedates that in the nerves, where the optic fibres may be preserved by their retinal ganglion cells for several years after complete functional blindness has occurred. The atrophic changes in the chiasm and the optic nerves are primary. See p. 79, Vol. I, of this *Encyclopedia.*

DISEASES AND INJURIES OF THE SPINAL CORD

Tumors of the cord. Papillitis and optic atrophy may occur from intracranial complications or from direct extension of a diffuse sarcoma. Rarely, optic neuritis may arise, apparently in the same manner as it does in myelitis.

Injuries of the cord. Amblyopia and amaurosis have followed, as claimed by Wharton Jones and others, sometimes at a long interval, injuries of the cord.

Tabes dorsalis; locomotor ataxia. Optic atrophy occurs in about 15 per cent. of cases of locomotor ataxia. There is a want of record among authors as to whether a short period of hyperemia precedes the atrophic changes.

In commencing atrophy, the nasal side of the papilla, which is normally pinker than the temporal side, becomes gray, and gradually the lamina cribrosa comes into view, atrophic cupping is developed, and the whole papilla presents a uniform, greyish hue. Later as connective tissue is developed in the lamina cribrosa, the greyish hue is changed to a glistening white and the retinal arteries and veins are reduced to the finest threads. This atrophic process advances from the periphery towards the axis of the optic nerve; the primary seat of the disease seems to be in the retina, commencing in the ganglion cells and the nerve fibre layer. The atrophy is most marked in or near the globe, diminishing towards the cerebrum. Changes in the tracts and chiasm are absent in the early and are slight even in the later stages. The so-called primary optic centers are not affected. See **Tabes dorsalis.**

Hereditary ataxy. Friedreich's disease. Oliver has observed optic atrophy in the incipient stage in one case with contracted fields but it must be regarded as occurring very rarely in Friedreich's disease. See p. 662, Vol. I, and p. 5161, Vol. VII, of this *Encyclopedia.*

Myelitis. As early as 1879 Erb and Steffan reported a case of dorsal, transverse myelitis with retro-bulbar neuritis and slight papillitis; since their time eighty odd cases of the sort have been added. In some instances pronounced choked disc was present, but primary optic atrophy is rare; nor is the retina affected.

Microscopic examination of the optic nerves show changes analogous to those found in the cord—softening, degeneration and, in most cases, the chiasma and the tracts have also been involved. See **Myelitis.**

Acute ascending paralysis. See p. 7007, Vol. IX, of this *Encyclopedia.*

GENERAL DISEASES

Hysteria. See p. 6123, Vol. VIII, of this *Encyclopedia.*

Graves' disease. Basedow's disease. Exophthalmic goitre. See Vol. II, p. 901, of this *Encyclopedia.*

Bright's disease. In addition to the fundus alterations described both under **Bright's disease,** p. 1296, Vol. II of this *Encyclopedia,* as well as under **Nephritis, Ocular relations of,** it may be added here that the ophthalmoscopic examination in *uremic amaurosis* in the large majority of the cases reveals nothing abnormal. Uremic amaurosis is more common in the acute varieties of kidney diseases; involvement of the retina and optic nerve, however, is not nearly so frequent as in the chronic forms of kidney troubles.

In typical cases the ophthalmoscopic appearance of *albuminuric retinitis* is characteristic. The optic nerve head appears opaque, reddish, and swollen, its limits not being clear and in some cases not even being visible. The posterior portion of the retina appears as a light membrane with opaque stripes. The peri-papillary zone which may surround the disc with a diameter of from four to six times its own size shows some extravasations of blood, mostly flame-like in shape. In the same zone white or yellowish spots surrounding the optic nerve may be found. The macula is often red and is surrounded by a wall of white foci of degeneration or by a characteristic star or halo-like arrangement of spots. The arteries are usually narrow, and are often outlined by whitish stripes. The veins are broad, of a dark-red color and more or less tortuous. Albuminuric neuro-retinitis is not infrequently seen and is characterized by a moderate inflammation of the optic nerve head. i. e., neuritis which is added to the albuminuric retinitis. Albuminuric neuritis or papillitis is rare, when seen it presents the same form.

Pregnancy. Groenouw (*Arch. of Ophthal.*, Vol. XXXVII, p. 165) found that the optic nerve was not infrequently involved in pregnancy in the form of optic neuritis or retro-bulbar neuritis. Uhthoff found 4 in 66 cases of chronic retro-bulbar neuritis to occur in women in advanced pregnancy. The author observed 10 cases where the optic nerve and retina during pregnancy and labor showed

changes which differ from the *retinitis albuminurica gravidarum.* See, also, the section on **Pregnancy, Ocular relations of.**

Diabetes mellitus; glycosuria; saccharine diabetes. The ophthalmoscopic appearances are chiefly a retinitis that resembles the albuminuric form with hemorrhages and white spots. In some of these cases the urine contains albumen, but there is no doubt that the retinitis may be due to diabetes without albuminuria. Diabetic retinitis differs ophthalmoscopically from the renal form in the absence of the soft-edged or wooly patches, and of the stellate arrangement of the white deposits around the yellow spot, and there is usually no papilledema. The hemorrhages are quite round, are deeper-seated and are generally due to a capillary aneurism and not to rupture of the larger vessels in the nerve-fiber layer. The condition is usually bilateral. Thrombosis of the central vein, embolism of the central artery, hemorrhagic glaucoma and detachment of the retina may also occur.

While papillitis is rare, still more rarely lipemia is seen associated with diabetes. The ophthalmoscopic appearances are then most striking, the retinal vessels containing fluid which looks like milk. The arteries are pale-reddish, the veins having a violet tint, which may be due to the lighter fat globules arranging themselves along the walls of the vessels, and the heavier red corpuscles remaining in mid-stream. See **Lipemia.**

Atrophy of the optic nerve in diabetes may be primary, coincident or secondary to a retinitis. The ophthalmoscopic appearance is the same as in atrophy from other causes. The neuritis in diabetes must be classed with the toxic or retro-bulbar types, and microscopic studies have revealed the special involvement of the papillo-macular bundles. See, also, p. 3924, Vol. V, of this *Encyclopedia.*

Diabetes insipidus; polyuria; polydipsia. The ocular symptoms are connected with the cause rather than with the condition called polyuria, and this opinion is undoubtedly correct in the cases of optic neuritis reported by Van der Hayden; in the unilateral optic nerve atrophy published by Laycock and the two cases of temporal hemianopsia reported by von Graefe and David. Probably in all these cases the cerebral lesion which gave rise to the ocular complications was also responsible for the polyuria. Retinal hemorrhages are occasionally seen. See, also, p. 3922, Vol. V, of this *Encyclopedia.*

Variola. Iritis, choroiditis and cyclitis may occur after small-pox and it has been calculated that uveal affections form 14 per cent., and corneal affections 35 per cent., of the eye complications of this disease. Circumscribed choroidal inflammation is rare but suppurative choroiditis of metastatic origin does sometimes occur. As a result of the

choroidal inflammation with implication of the vitreous humor, posterior polar cataract occasionally develops. Glaucoma has been observed during variola. Adler reports three cases of neuro-retinitis diffusa and nephritica which appeared during the stage of dessication.

Knies has recorded hemorrhages into the optic nerve.

Dermal affections and ocular diseases. See p. 3834, Vol. V, of this *Encyclopedia*.

Diseases of the digestive tracts. See p. 4108, Vol. VI, of this *Encyclopedia*.

Rubeola; morbilli; measles. When measles is complicated with meningitis optic neuritis and even complete blindness from atrophy may ensue. Some of these cases of optic atrophy mây have been due to a retro-bulbar neuritis of basal origin, or they may be secondary to an otitis media. Metastatic choroiditis has been observed during an attack of measles. See, also, **Measles.**

Scarlatina. The amaurosis or the amblyopia associated with scarlet fever is generally the result of renal complications, and quite a few of such cases are on record. The amaurosis may be present without any observable changes in the fundus. Pflüger has, however, observed a papillo-retinitis without kidney affection and Leber records a case of a boy who became blind without ophthalmoscopic signs and with normal urine. See, also, **Scarlatina.**

Erysipelas. The most serious complication of erysipelas is atrophy of the retina and optic nerve, which is the usual cause of post-erysipelatous blindness. In all observed cases there is extreme contraction of the retinal vessels, especially of the arteries. Foster attributes the retinal lesion to a direct transmission of the inflammation along the sheaths of the vessels rather than to a compression of the optic nerve, exercised through the medium of the orbital tissues. Knapp reported the ophthalmoscopic evidences of a case, and found the fundus was milky-white, with dark, almost black, tortuous vessels radiating from the disc, which was itself invisible. There were numerous dark-red hemorrhages throughout the fundus. White atrophy followed, with the presence of the perivascular lines along the retinal vessels. He concluded that the intra-ocular changes are the result of the compression of the central vessels caused by an orbital cellulitis. Vossius describes a case of neuro-retinitis with detachment of the retina, and retinal and sub-retinal exudation, which followed on several occasions three or four attacks of facial erysipelas. See, also, p. 4510, Vol. VI, of this *Encyclopedia*.

Diphtheria. Defects of sight not to be accounted for by the paralysis of accommodation do occur after diphtheria, though rarely. Con-

centive contraction of the fields of vision, with defective color vision, has been recorded by Jessop and Nagel, with a distinct neuritis.

Pertussis; whooping cough. Roedelius (*Archiv für Kinderheilk.* LXII, No. 3) records a case of optic atrophy in a child who died a few weeks after having had whooping cough. All other possible causes could be excluded. The writer was able to find the reports of six other cases, one recovering spontaneously and another after spinal puncture. A woman of 40 developed papillitis and retinal hemorrhages in connection with a protracted case of whooping cough.

Dysentery. The ocular symptoms may be divided into two groups, the first, due to special infection which produces the dysentery, includes paresis of accommodation, atrophy of the papilla, opacities of the vitreous and false granulations; the second group, due to secondary infections, includes keratitis and choroiditis, produced by the passage of the germs from the large intestines into the general circulation to the eye. See, also, p. 4106, Vol. VI, of this *Encyclopedia.*

Influenza. The fundus changes are usually limited to the retina and the papilla. Retrobulbar neuroretinitis is quite frequently seen, due to the involvement of the frontal, ethmoidal or sphenoidal sinuses; however, some of the cases are the result of direct action of the influenza toxins, and it may follow meningitis. There is usually a central scotoma, with reduction of the visual acuity and the visual fields.

E. A. Thomson (*Annals of Ophth.*, p. 249, Vol. XIX) reports a case in which there was a large patch of retino-vascular change at the lower edge of the disc. Two venous trunks enormously dilated and tortuous; arteries greatly reduced in size. Arterio-sclerosis and kidney lesions were excluded. See, also, p. 6195, Vol. VIII, of this *Encyclopedia.*

Cholera. Ophthalmoscopic examination of the fundus during the algid period shows that there is a contraction of the retinal arteries, whose color appears of a dark-red. The retinal veins retain their normal diameter and contain very dark blood. Graefe has observed the blood-currents to be interrupted in the veins of the retina. Williams has reported hemorrhages in the choroid. See, also, p. 2112, Vol. III, of this *Encyclopedia.*

Malaria. Ocular complications occur in 10 per cent. of the cases of malaria. Authors agree that optic neuritis, neuro-retinitis, and retinal hemorrhages are the most frequent as well as the most important fundus changes in this disease. Sulzer studied a large number of cases of acute and chronic malarial fever in the island of Java. He divides the ocular complications into two groups according as they accompany either the chronic or the acute form of the disease.

In the first class, and in order of frequency, he places: 1, chronic optic neuritis, seen in grave cases; 2, diffuse infiltrations of the vitreous body; 3, multiple, punctiform, peripheral hemorrhages of the retina; and 4, persistent amaurosis. In the second class he places: 1, periodical amaurosis and amblyopia without ocular lesions; 2, diffuse fundus lesions predisposing to affections of the macula; and 3, large peripapillary and macular hemorrhages in the retina.

Uhthoff found 17 cases of optic neuritis in 253 cases due to infectious diseases. It is doubtful if primary optic atrophy ever occurs in malaria. See, also, **Malaria.**

Typhoid fever. Neuro-retinitis has been observed in typhoid fever by Carpenter and others. Clothier (*N. Y. Med. Journal,* April 10, 1909) studied the fundus in a patient just before the onset of the typhoid fever and found it normal. Three weeks after the fever began an ophthalmoscopic examination revealed a well-marked neuro-retinitis which cleared up in a month's time. See, also, **Typhoid fever.**

Sinusitis. See p. 1810, Vol. III, of this *Encyclopedia.*

Dengue. See p. 3743, Vol. V, of this *Encyclopedia.*

TOXIC STATES

Alcohol, ethyl and methyl. The fundus changes in these intoxicants are fully described under **Toxic amblyopia.** See, also, p. 303 and p. 215, Vol. I, as well as p. 2510, Vol. IV, of this *Encyclopedia.*

Tobacco. See p. 303, Vol. I of this *Encyclopedia;* also under **Toxic amblyopia.**

Carbon disulphide. Central vision is usually most affected by a retrobulbar neuritis, the fields showing a central scotoma for red and green, rarely peripheral contraction may be found. Blindness is very rare, but considerable amblyopia with partial atrophy may persist. See **Toxic amblyopia,** and p. 1403, Vol. II of this *Encyclopedia.*

Iodoform. Amblyopia from iodoform may show itself by means of the ophthalmoscope as a slight haziness of the disc margin or, finally, complete atrophy. There may be seen in the advanced cases a central color scotoma. See, also, **Toxic amblyopia,** and p. 6569, Vol. IX, of this *Encyclopedia.*

Ioduret and thiuret. Poisoning from these two drugs has caused contraction of the color field and central scotoma with degenerative changes in the temporal half of the disc. See p. 6574, Vol. IX, of this *Encyclopedia.*

Nitrobenzol and dinitrobenzol. In poisoning from these agents ophthalmoscopic study reveals moderately overfilled arteries, venous hyperemia, pale or blurred optic discs, and small retinal hemorrhages. See p. 3973, Vol. V, of this *Encyclopedia.*

Arsenic. The various compounds of this poison have produced amblyopia with the following lesions: Retrobulbar neuritis with sector discoloration in the temporal half of the optic papilla and paracentral negative scotoma for red and green; optic neuritis; optic nerve atrophy. See p. 605, Vol. I, of this *Encyclopedia.*

Atoxyl, arsacetin and other arsenical compounds. Paderstein (*Berlin Klin. Wochensch.,* May 24, 1909) collected the records of twelve cases accompanied by visual disturbances due to the use of atoxyl and arsacetin. Of these twelve cases one recovered normal vision and four became totally blind. His own case showed optic atrophy after the use of atoxyl.

Some other drugs of the organic arsenical group likely to produce blindness are soamin, orsudan, sodium cacodylate and salvarsan.

Atoxyl is, however, the most toxic, optic atrophy occurring in 20 per cent. of the cases where it has been used, sodium cacodylate being the least toxic of all. See p. 605. Vol. I, of this *Encyclopedia.*

Lead. The ocular complications produced by lead poisoning show great variety. Bilateral, sudden, more or less complete amaurosis is usually associated with little or no change in the fundus. The lesion of the optic nerve is usually inflammatory, very rarely primarily atrophic. In 10 per cent. of the cases ophthalmoscopic examination is negative; in 11 per cent. there is hyperemia of the disc, in 30 per cent. papillitis, in 8 per cent. choked disc, in 12 per cent, neuroretinitis, in 29 per cent. partial or general post-neuritic atrophy.

Changes in the retinal vessels are very frequent—constriction and white lines along the vessel walls. Retinal hemorrhages and white spots occur at times. Ring scotoma is rare, temporal hemianopsia has been reported, and the presence of an homonymous hemianopsia is indicative of encephalitis saturnina, occasionally of involvment of the optic tract with hemiparetic symptoms.

Anatomical observations have shown interstitial proliferations and thickening of the sheaths in the optic nerves, hyaline degeneration of the vessels of the nerve, retina and choroid. See, also **Toxic amblyopia.**

Phosphorus. The fundus changes occur early in this toxemia. These are retinal hemorrhages followed later by fatty degeneration of the retinal tissue itself, which, should the patient live long, sets up secondary changes in the optic nerve. See **Toxic amblyopia.**

Coal-tar products. Of the various products *aniline* is the most active in producing poisoning, either alone or as an impurity in nitrobenzol. Antifebrin and antipyrin may cause a temporary complete blindness, accompanied by a marked anemia of the optic nerve and the retina, with shrinking of the vessels and contraction of the visual field.

Cases of amblyopia caused by anilin oil have been reported by Marchesi and Veasey. The latter found contraction of the fields, central scotoma and slight papillitis.

The retinal changes noted after the administration of large doses of the coal-tar derivatives are no doubt due to changes in the blood supply of the retina. See **Aniline**, p. 479, Vol. I, of this *Encyclopedia*.

Opium or its alkaloids. It appears that the excessive use of opium, or large doses of this drug consumed within comparatively short periods of time, may produce (though it rarely does) amblyopia or even complete blindness, with a slight veiling of the edges of the papilla. There may be present at times a pallor of the temporal half of the disc, with right-sided half-blindness and left-sided concentric contraction of the visual field. Raymond has reported an atrophy of the optic papilla with central scotoma. Opium may be classified with those drugs, clinically at least, which produce an intoxication-amblyopia with lesion of the papillo-macular bundle. See **Morphia**; as well as **Toxic amblyopia.**

Vanilla. Guerin (*Annales d' Oculist*, 1895) and others reported congestion of the optic discs, and occasionally retinitis and chorio-retinitis.

Stramonium and ergot (see p. 4506, Vol. VI, of this *Encyclopedia*) are described, as to the fundus findings of the intoxication, under **Toxic amblyopia,** as also are *carbonic monoxide* and *dioxide* (Vol. II, p. 1406).

Quinine. This drug in toxic doses produces marked fundus changes. Ophthalmoscopically the striking features are extreme contraction of the retinal vessels and pallor of the disc.

There can be no doubt that the essential factor in the disorder is the retinal ischemia. See **Toxic amblyopia**; as well as **Quinine.**

Filix mas: aspidium. The chief ophthalmoscopic features observed in poisoning from this agent are extreme pallor of the disc with sharply-defined edges. In many cases the retinal vessels show abnormality, especially constriction. Marked retinal changes and bright, white spots have been observed, but it is known that filix mas may cause nephritis and the retinal changes may be due to this complication.

Serpent virus. Congestion of the optic papilla and amaurosis lasting for months have been reported by Laurencao. S. Wier Mitchell observed retinal hemorrhages in experiments with serpent virus. See **Toxic amblyopia.**

Sinusitis. The fundus changes are fully described under **Cavities, Neighboring**, to which heading the reader is referred.—(W. R. P.)

Ophthalmoscopy, Metric. Ophthalmoscopy as applied to the measurement of the refractive power of the eye.

Ophthalmospasm. Ocular spasm; spasm of either the external or internal eye muscles.

Ophthalmospintherism. A visual affection in which numerous sparks or luminous spots (phosphenes) are seen.

Ophthalmostasis. Fixation of the eye with the ophthalmostat.

Ophthalmostat. An instrument for fixing the eye and controlling its movements for purposes of examination or operation. See p. 5212, Vol. VII, of this *Encyclopedia.*

Luer's Ophthalmostat.

Ophthalmostatometer. An instrument for determining the degree of protrusion of the eyeball; an exophthalmometer. See p. 4597, Vol. VI, of this *Encyclopedia.*

Ophthalmostatometry. The process of determining the relative position of the eyes in the orbits.

Ophthalmosteresis. (Obsolete.) The loss or absence of one or both eyes.

Ophthalmosynchysis. (Obsolete.) An effusion into the interior of the eye; a mixture of the fluids of the eye.

Ophthalmothermometer. A device for recording local temperature in eye diseases.

Ophthalmotologist. A little used synonym of ophthalmologist.

Ophthalmotology. A synonym of ophthalmology.

Ophthalmotome. A sickle-shaped knife invented by Pellier de Quengsy for the performance of the cataract operation in the simplest and speediest manner possible. When this instrument was employed, no other was used at any stage of the operation. For a description, together with an illustration, of the instrument, see, in this *Encyclopedia*, **Pellier de Quengsy.**—(T. H. S.)

Ophthalmotomy. A term used by the older writers for an anatomical dissection of the eye; also, enucleation.

Ophthalmotonometer. The name given by Coburn to an instrument for the determination of the tension of the eyeball. See **Tonometer**; also **Examination of the eye**; as well as **Glaucoma.**

Ophthalmotopsis. An old term for prolapse of the eyeball.

Ophthalmotoxin. A toxin formed on injection of emulsion of the ciliary body.

Ophthalmotrope. The Knapp apparatus for demonstrating the movements of the eyeball by the action of the ocular muscles is described and pictured on p. 6860, Vol. IX, of this *Encyclopedia*.

Ophthalmotropometer. An instrument for measuring the excursive movements of the eyes from the primary position.

Ophthalmotropometry. The measurement of movements of the eyeball.

Ophthalmo-typhoid reaction. Chantemesse precipitates a strong solution of soluble typhoid toxin with absolute alcohol and obtains a powder of which a fiftieth of a milligram dissolved in a drop of water and instilled into the lower lid of a typhoid patient gives a characteristic reaction, consisting of redness, lachrymation and a serofibrinous exudate. The affected eye can be distinguished from the other for two or three days after the instillation. In people who have other diseases, or in well people who have not recently experienced typhoid, slight redness and lachrymation occur, but disappear in three or four hours, and by the next day the eye appears like the other. The temperature and general condition are not affected by the experiment. Chantemesse believes that the reaction may give a very early sign of typhoid and that it is without danger.

It must be remembered that as a prelude to this test the eye should be carefully examined to insure the absence of ocular disease; otherwise the reaction may be masked or the injection of the vessels and secretion resulting from previously existing disease attributed to the reagent. In any event we now possess other and more satisfactory tests for the typhoid poison.

Ophthalmotyphus. A word employed by Eisenmann for an epidemic contagious ophthalmia.

Ophthalmoxerosis. Xerophthalmia.

Ophthalmoxysis. (Obs.) Scarification of the vessels of the conjunctiva.

Ophthalmoxyster. An instrument for scraping the conjunctiva.

Ophthalmoxystrum. A small instrument formerly used for scraping the cornea and conjunctiva, or for scarifying the inner surface of the eyelids.

Ophthalmozygomatogramma. The oculo-zygomatic line.

Ophthalmula. (Obs.) A cicatrix on the eyeball.

Ophthalmuria. A supposed metastasis of the urine to the eyes.

Ophthalmyalos. OPHTHALMYALUS. (Obs.) The vitreous humor.

Ophthalmydrorrhea. A watery discharge from the eyes.

Ophthalmymenitis. An old term for inflammation of one or more of the coats of the eye.

Opiate saturnine collyrium. A collyrium made by mixing 2 drops of vinegar of lead, 1 grain of extract of opium, and 1 oz. of rose-water; or 1 scruple of vinegar of lead, 1/2 pint of water, and 1 oz. of tincture of opium.

Opifex bifocals. A patented form of bilenticular spectacles.

Opifex circumductionis. Superior oblique muscle.

Opiophagen. (G.) Opium and morphia addicts.

Opisthobares. A collyrium formerly used for granular lids.

Opisthosynechia. (Obs.) Posterior synechia.

Opium. MECONIUM. SUCCUS THEBAICUS. The dried juice from the unripe capsules of the opium poppy—*papaver somniferum*—yielding not less than 9 per cent. of crystallized morphia. The soluble preparations of opium are incompatible with alkalies, copper salts, tannin, mercuric bichloride, and silver nitrate.

Almost every known preparation of this drug has been used in the treatment of eye diseases, but aqua opii. (P. G.), laudanum (tr. opii), tincture of deodorized opium, solution of morphia and ext. opii form the common topical remedies. Owing to its action as a miotic when given in full doses internally it has been prescribed for the pain and insomnia accompanying glaucomatous attacks.

The application of opiates directly to the eye tissues arose from their well known general action. Even von Graefe often prescribed an eye wash composed of equal parts of water and laudanum for the relief of eye pains. However, although dionin (q. v.) and other remedies derived from opium are among the most useful local analgesics we have there is probably no ground for the assumption that opium is a local anesthetic, as we know that it acts through the great nerve centers and not at all, or but feebly, on filamentary endings. Experience has also proven the futility of depending upon such supposed soothing or pain-destroying local applications and they are rarely employed, except as part of an occasional collyrium or ointment, in both of which (owing to their limited absorption) they seem to be practically inert.

Examples of such employment will be found in Scott's mixture (q. v.), and in a domestic prescription of Schmidt-Rimpler for the relief of the burning sensations and pain of conjunctival hyperemia: viz.,

℞ Zinc. sulphatis, 0.5 (gr. vii), tinct. opii, 1.0 (m xvi), aquæ fœniculi, 50.0 (f℥ i ʒ vss), aquæ dest., 100.0 (f ℥ iiiss).

Both prescriptions act as promptly with the opiate omitted.

In deprecating the employment of tinctures of opium as topical remedies one must not forget the mildly antiseptic and stimulating effects of the alcohol they contain. Thus, Ohlemann advises one part of tincture of opium to five parts of distilled water as a stimulating collyrium in partially healed ulcers. The German pharmacopeial *tinctura opii crocata*, prescribed as a local analgesic in eyewaters, corresponds to our *vinum opii*, the so-called Sydenham's laudanum. It has about the same strength as the ordinary tincture of opium.

Lawson (*Text-book*, p. 538) suggests the following as a soothing application to the conjunctivæ: ℞ Ext. opii. liq., fl. ʒi, acid. hydrocyanici dil., m. xxx, aquæ dest. ad., fl. ℥viii.

The following mixture is recommended by Theobold (*Text-book*, p. 512): ℞ Ext. opii., gr. x (0.60), acid. boracic., gr. xl (2.70), aquæ dest., fl. ℥iv (60.00).

He believes it to be valuable in any painful condition of the eye, especially in traumatic lesions, in keratitis, iritis, glaucoma, acute inflammation of the lachrymal sac, lid abscess, panophthalmitis, cellulitis of the orbit, etc. It is also useful in asthenopia in miliary choroidoretintis dependent upon strain of accommodation, and in the choroidoretinitis of high myopia. It may be given a poultice-like action by covering the pad on which it is applied with oiled-silk or oiled-muslin; or it can be applied hot if found more soothing.

For the employment of opium as an ophthalmic remedy in antiquity, see **Poppy**.

Opobalsamum. Opobalsamatum. A "balm" used by the ancients as an application to the lids in cases of granular ophthalmia or to the granules *(aspritudines)* themselves. The objective *melinum*, often used to qualify the term, is supposed to refer to the yellow color of the remedy. See the *London Lancet*, April 11, 1914.

Opopanax. The juice of a plant known in antiquity as *Panax*.

Opotherapy. A name for organotherapy—the treatment of disease by the administration of animal extracts.

Oposuprarenalin. A patented preparation of the suprarenal capsules of animals.

Opposite colors. See under **Complementary colors.**

Opsiometer. A form of optometer, invented (together with its name) for Serre d'Uzès. It consisted of a horizontal board, on which was placed a needle which marked the points of nearest and farthest distinct vision. The instrument is no longer in use.

Opsis. (L.) Vision.

Opsonic index. This term expresses the relation between the normal opsonin (q. v.) content of the blood serum and the amount actually present in a given case; in other words, the resisting power of the blood against bacilli as compared with the normal. It is determined by comparing the amount of phagocytosis occurring in suspensions of leucocytes, bacteria, and normal serum with that taking place in a similarly prepared suspension to which has been added in place of the normal serum, the immune serum to be tested. The leucocytic suspension is prepared by allowing about 20 drops of blood from a puncture of the finger or ear to flow into a tube of .85 per cent. sodium chloride solution to which 1 per cent. sodium citrate has been added. Upon centrifugalization, the red corpuscles collect in the bottom of the tube, and the leucocytes in a lighter colored layer just above, the so-called leucocytic cream. After a second washing with sodium chloride solution, the supernatant clear fluid is pipetted off, and the leucocytic layer, together with a certain unavoidable number of red cells, is removed for use in the opsonic determination. The bacterial suspension is obtained by washing off with salt solution the bacterial growth from a young (preferably an 18 to 24 hour growth) culture on agar or other solid medium, of the organism in question. The suspension is centrifugalized to remove clumps of the bacteria and the density of the resulting opalescent fluid adjusted so that it contains a suitable number of organisms. This is important, for if too many or too few bacteria are present in the mixture of leucocytes and serum, errors in the estimation of phagocytosis will result. For tuberculo-opsonic determinations the residue of bacilli after the preparation of old tuberculin is frequently used. The organisms are washed free from glycerine, etc., are ground up in a mortar, suspended in 1.5 per cent. salt solution, and the resulting suspension centrifugalized to remove the clumps. Difficulty may be met with in obtaining homogeneous suspension of certain organisms such as the gonococcus and meningococcus, but this can be avoided to a large degree by the use of the young cultures (12-18 hours).

The serum for the test is collected from a needle puncture in the finger or ear of the patient, two or three drops of blood in a capillary U-tube being sufficient. After the blood has been allowed to clot, the serum is collected by centrifugalization. The normal control serum is obtained in the same way by mixing the sera from two or three normal persons.

Equal volumes of the serum, leucocytic suspension, and bacterial emulsion are mixed and incubated at 37° C. for 10 to 20 minutes. A

convenient pipette for mixing is obtained by drawing out a glass tube into a fine capillary several inches in length, and then bending it at right angles. A mark is placed at a distance of an inch or so from the end, and the serum, leucocytes and bacterial emulsions are drawn up successively to the mark, allowing a small air bubble to intervene between each volume. The contents of the tube are expelled upon a glass slide and mixed by drawing gently back and forth into the pipette. The mixture is returned to the pipette, which is sealed in the flame. A similar procedure is carried out with the mixture or pool of normal sera, and the two pipettes incubated at 37° C. for 10 to 20 minutes. Smears are made from each pipette, fixed and stained. Fixation may be accomplished by heat, or by the application of ethyl or methyl alcohol, or saturated aqueous solution of corrosive sublimate. A number of staining solutions are in use. Carbolthionin, J. H. Wright's stain, or methylene blue give good results. For tests with the tubercle bacillus the ordinary carbol-fuchsin or anilin-fuchsin is used followed by methylene blue after decolorization.

The degree of phagocytosis is determined by counting the number of organisms taken up by a consecutive series of 50 to 100 leucocytes, and calculating the average number per leucocyte. The opsonic index is found by dividing the average number of organisms taken up per leucocyte in the mixture of serum to be tested, by the average number per leucocyte in the normal control serum mixture. Thus, if the average in the test serum mixture is 3 organisms per leucocyte, and the average in the control is 5, the opsonic index is 0.6.

A good example of the application of the opsonic index to investigation of the subject in disease is furnished by Calderaro's (*Clinica Oculistica*, Jan.-April, 1915) experiments in various forms of diabetes. He examined animals suffering from each of the three varieties of glycosuria, viz., the form presented when phlorizin had been employed, that in which adrenalin was given, and that in which the pancreas had been removed entirely, and sums up his conclusions thus:—

(1) That in animals thus rendered diabetic the first and second aqueous humor remain alkaline, and the urine acid. (2) That in the phlorizin-treated animals no glucose is found in the aqueous, but there is in the other two groups. (3) That in experimental diabetes there is always diminuation of the opsonic efficiency of the blood serum and consequently of the second aqueous; this occurred early in the adrenalin cases and in those de-pancreatinized, but only later on in the phlorizin cases. (4) That the opsonic efficiency of the first aqueous differed in no way from that of the normal animal. (5) That in experimental diabetes with lowering of the opsonic efficiency of blood

serum and of aqueous humor, subconjunctival injection of 10 per cent. solution of chloride of sodium and subsequent infection of the cornea with staphylococcus pyogenes excited a flow of opsonins into the first aqueous, but slowly and to a slight degree as compared with the normal animal. (6) That this diminution of the opsonic efficiency in animals rendered diabetic stands in relation not to the presence of glucose in the aqueous but to the similar reduction in the efficiency of the blood serum. (7) That the enhanced gravity of corneal infection by the staphylococcus pyogenes in the diabetic depends above all upon this slower and feebler transit of opsonins into the aqueous and the lymphatic spaces of the cornea. (8) That the alteration of the ciliary epithelium produced by the injection of fluoride of sodium into the anterior chamber assists the passage thither of glucose and of the opsonins in the blood-stream. (9) That the lowered opsonic efficiency of blood serum and of aqueous in experimental diabetes can be raised to a higher level by the introduction of a vaccine.

See, also, p. 857, Vol. II of this *Encyclopedia;* as well as under **Opsonin.**

Opsonin. That constituent of the blood-serum of a normal animal which renders bacilli or blood-cells prone to be absorbed by phagocytes. Following the attacks of bacteria they are increased, as are other known immune substances—bacteriolysins and agglutinins for instance—for defensive purposes.

Zur Nedden (*Zeistschr. f. Augenheilk.,* April, 1908) has studied the opsonins in the eye by their action in promoting phagocytosis of the diplobacillus of Morax and Axenfeld, the staphylococcus albus, the streptococcus, the pneumococcus, and the dysentery bacillus. In the conjunctival secretion he found that a thin blennorrheal discharge had a phagocytic influence, more powerful as the discharge was more profuse, but as the discharge became thick this power was lost. The secretions of the conjunctiva due to diplobacilli, pneumococci, and Koch-Weeks bacilli seemed to have no such power. He suggests possibly that it was exhausted by the large number of bacteria present. The lachrymal and normal conjunctival secretions show no opsonic power.

The normal aqueous has no phagocytic influence, but if the anterior chamber be tapped repeatedly, at intervals of a few minutes, the aqueous obtained soon exerts a marked opsonic influence, which, however, passes away in a few hours after the last tapping. Inflammatory processes in the eye also increase the power of the aqueous to promote phagocytosis, in proportion to the severity of the inflammation. To a lesser degree subconjunctival injections of salt solution increase opsonic power. Coagulability of the aqueous indicates the presence of opsonins.

In the vitreous the opsonic power is similarly affected, except that it is lost when the humor becomes overloaded with bacteria. In the cornea of the normal eye opsonins were not found. But they appeared under the influence of inflammation, etc., as in the aqueous. In the lens no opsonins were found, however intense the inflammation of adjoining parts. The practical lesson zur Nedden draws from his studies is that the best treatment of infectious processes is that which strengthens and renders more effective the natural curative powers—that which increases the influence of these protective bodies—and not one that directly attacks the cause of the disease. See, also, **Opsonic index,** and p. 857, Vol. II of this *Encyclopedia.*

Optactin. The visual axis or line of sight.

Optic. OPTICAL. 1. Relating or pertaining to vision or sight; visual; subservient to the faculty or function of seeing. 2. Of or pertaining to the eye as the organ of vision; ocular; ophthalmic. 3. Relating to or connected with the science of optics; based on or constructed in accordance with the laws of optics; as, *optical* laws; *optical* instruments.

Optical aphasia. In this condition objects seen cannot be named from memory in spite of the fact that they are recognized visually and that their names can be repeated when heard or read. The association between visual impression and word-formation (memory) is interrupted. The name for the object may be remembered and given if characteristic properties recognizable by other senses are present; for instance, the word "bell" is not found in looking at a bell but if the bell is sounded the word will be remembered and given; or a knife is named only after it is held in the hand. That an object is recognized by the aphasic as far as its function is concerned before this function is demonstrated is shown by such statements as "serves for cutting," "used for ringing," etc. Through such a complex association the word may be found without direct stimulation of other sense-centers, but in this case there must exist an association between the optic and at least one other sense-center, and an association between the latter and the speech centers, which proves that the acoustic and motor speech centers are intact. The more the optic characters prevail over other characteristics of the objects the more marked optic aphasia will be noticed. This will be pronounced in that form of color-vision in which optic aphasia frequently is mistaken for color-blindness; the latter possibility can be eliminated by submitting the patient to Adler's test (see p. 5086, Vol. VII of this *Encyclopedia*) in which an optic aphasic will yet choose the correct colors. On account of difficulties in naming optically submitted objects (or persons) the use of speech suffers in general especially for concrete impressions.

The disorder is most typical if the posterior part of the second and third temporal convolution becomes diseased, because in such cases those tracts are affected which connect the center of optic memory of the occipital lobes with the left acoustic speech center. Optic aphasia is frequently complicated by right hemianopsia, occasionally with sensory aphasia—on account of simultanteous destruction of the gyrus angularis. Brain abscesses are the most common cause of optic aphasia.

Optical aximeter. See **Lens measurer,** p. 7410, Vol. X of this *Encyclopedia.*

Optical axis. In an optical system the common normal to the surfaces.

Optical axis of the eye. An imaginary line drawn from the centre of the cornea to a point midway between the macula lutea and the optic disc.

Optical box. See p. 6881, Vol. IX of this *Encyclopedia.*

Optical centre of a lens. The point through which incident rays pass without change of direction.

Optical centres. See p. 6547, Vol. IX of this *Encyclopedia;* also **Centers, Visual.**

Optical circle. In *physics*, a graduated circle, fitted with the necessary appliances, used for illustrating the laws of refraction and reflection, or, when accurately constructed, for measuring interfacial angles, refractive indices, etc.

Optical constants. The cardinal points of the eye. See p. 1413, Vol. II of the *Encyclopedia.*

Optical contact. A contact between two transparent surfaces (as when two varieties of glass are united to form a single lens), so that there is no change in the direction of rays of light passing through the two media; also the contact of pigments with glass, so that there is no reflection from the painted side.

Optical densimeter. An instrument for ascertaining the comparative optical density of a solid or liquid.

Optical density. The power possessed by a medium of retarding the rate of transmission of light. See **Density, Optical,** p. 3817, Vol. V of this *Encyclopedia.*

Optical glass. Glass adapted for optical purposes.

Optical interval. In the case of a double positive lens system the distance between the second principal focus of one lens system and the first principal focus of the other on the same axis. In the case of the microscope it is called the optical tube length.

Optically. As regards sight or the laws of vision; in accordance with or with reference to the science of optics or the use of optical instruments; by optical means.

Optical meteorology. The science of the luminous phenomena of the atmosphere.

Optical rotating power. The property possessed by some substances of rotating the plane of polarization of a ray of polarized light through a certain angle.

Optical square. A surveyor's instrument used for laying out lines at right angles to each other. It consists of a circular brass box containing two principal glasses of the sextant, the index- and horizon-glasses, fixed at an angle of 45°.

Optical system. An arrangement of optical elements, such as mirrors and lenses, for the deviation of light rays.

Optical thermometer. An instrument used for determining very high temperatures, based on the principle that the amount of rotation of the plane of polarization in certain crystals varies with the temperature.

Optic angle. VISUAL ANGLE. 1. The angle included between the two lines drawn from two extremities of an object to the first nodal point in the eye; the visual angle. 2. The angle which the visual axes of the eyes make with one another as they tend to meet at some distance before the eyes. 3. The angle between the optic axes in a biaxial crystal.

Optic aperture. See p. 533, Vol. I of this *Encyclopedia*.

Optic atrophy. In addition to the rather full account of this subject on p. 688, Vol I, of this *Encyclopedia* it may be added here that Behr (*Ophthalmic Year-Book*, p. 237, 1916) reminds us in this connection that cerebrospinal lues is due to a spirochete infection of the meninges and their appendages, while tabes dorsalis and paralysis are due to an infection of the cerebral substance itself. The question of curability depends on the earliest possible diagnosis. *Disturbance of dark adaptation is the first symptom of tabetic degeneration of the optic nerve.* A case is reported in which after early diagnosis the process in the optic nerve was arrested by continued anti-luetic treatment. Some authors, however, think any treatment of tabes contraindicated when the optic nerve takes part in it, since through it the optic nerve affection can be rapidly made worse. Behr has seen four cases in which immediately after specific treatment a great deterioration appeared which in a short time produced blindness in both eyes. According to Wilbrand, danger through the therapy threatens especially in those cases in which with relatively normal outlines for white there is at an early stage a deterioration in the color fields and a diminished central acuity of vision. There are thus three types of tabetic optic atrophy in which anti-syphilitic therapy is contraindicated.

1. Diminution of central visual acuity, early loss of color sense with normal, or nearly normal outlines for white.

2. High concentric contraction of the visual field, the outlines for white the same as for colors, normal or nearly normal visual acuity.

3. Insignificant field disturbances which concern white more than colors (here, too, joining their outlines) normal or nearly normal visual acuity, with ophthalmoscopically well pronounced atrophy. Strong subjective phosphenes.

In all other cases a specific treatment of the optic nerve process is not only permitted, but highly indicated, and as energetically and for as long a time as possible. Encouraging results have recently followed the removal of 10 cm. of cerebrospinal fluid once or twice weekly during energetic specific treatment.

Calhoun reports a case of optic atrophy following uterine hemorrhage. The blindness lasted three weeks. Slow restoration of sight took place. The fields showed a partial hemianopsia. Bronner reports a case of unilateral optic atrophy after exposure to an arc light. The patient, a woman, had been intently watching an arc light covered with a neutral glass for about one hour. Immediately thereafter she found the vision of the left eye very poor. Six days later vision equaled fingers at 1 foot. The pupil was slightly larger than its fellow. The retina was congested in the region of the macula. The optic nerve was apparently normal. Vision rose to 6/12. The field was greatly contracted and there was a relative central scotoma. The optic disk became white. Fisher saw complete loss of vision in one eye follow five days after the injection of olive oil and lanolin for the removal of wrinkles. The optic nerve was atrophic. To avoid implication of the optic nerves he advises that when injections are made for cosmetic purposes in the vicinity of the orbit, pressure should be made at the inner side of the orbit at the time of the injection and for some time thereafter.

Lanier points to Derby's figures of seventy-one instances in 117 cases of optic atrophy in which no definite cause could be assigned, to show our limitations in etiology. In the first case of optic atrophy in acute myelitis and polyneuritis reported by Ulrich the papilla was not at first affected, but in the course of the disease became congested and ill-defined, with final loss of capillarity. Three months after recovery from the myelitis vision was ¼ without visual field defects. In the second case, eighteen months after loss of sight in one eye from retrobulbar neuritis, the other eye became affected, apparently the result of inflammatory disease of the optic tracts beginning in the chiasm and involving the optic nerve later. There was at first a nasal

hemichromatopsia which developed into a complete nasal hemianopsia with gradual contraction of the temporal field and a half ring scotoma. After three and a half months the visual field was recovered except for a relative scotoma. Vision also improved. After a prolonged attack of acute transverse myelitis, the patient died. An interesting point was the long period intervening between the ocular symptoms and those of the spinal cord.

Velter states that in insular sclerosis the sclerotic deposits may be found in any part of the visual paths, although they affect by preference certain spots, such as the region of the central retinal vessels, the intracranial segment of the optic nerve, and the chiasm. The most important and constant histologic changes were found in the nerve fibers, the neuroglia and the blood-vessels. The essential characteristic of these lesions is a change in the medullary sheath, in the beginning a disintegration of the myelin and finally a complete demyelization. The axis cylinder as a rule shows no secondary degeneration; some, however, show hypertrophy, atrophy, swellings, bifurcations or even dissociation. In the neuroglia there is an active cellular proliferation in recent plaques with usually an increase in the number of capillaries, the walls of which show round-cell infiltration. In the optic nerve the texture of the plaque shows a peculiar fasciculated arrangement due to the existence of connective-tissue septa in the optic nerve. These anatomical changes explain why complete blindness does not follow the seemingly profound changes in the optic nerve and chiasm and explains the rarity of hemianopsia. The remarkable improvement in the visual defects is due to regeneration of the nerve fibers.

Suker reports a case of optic atrophy in a man 50 years of age who had multiple sclerosis. The nodules of sclerosis are situated almost at the entrance of the nerve into the chiasm. In the same eye, towards the nasal side of the disk, are two islands of opaque nerve fibers separated by an area of normal retina between themselves and the optic nerve. No opaque fibers at the disk in any quadrant.

An article by Cushing and Walker (*Ophthalmic Year-Book*, p. 249, 1916) on studies of optic nerve atrophy in association with chiasmal lesions presents an enormous amount of work. Eight of their two hundred odd cases of hypophyseal tumor died and came to autopsy, allowing of the endeavor to trace the course of the degenerated nerve fiber bundles by various stains and to associate them with the visual defects found antemortem. In none of the cases was there any ophthalmoscopic evidence of the secondary changes due to choked disk, though in some of them a low grade of recent edema was superimposed on

the picture of so-called primary atrophy. From this series, the clinical details of which may be omitted, the authors concluded:

(1) The anatomical changes in the extra-cellular pathway in cases of pressure against tract, chiasm, or nerve are far less sharply cut than the functional disturbances determinable by the perimeter would lead one to expect. (2) Even in cases of hemianopsia with a vertical meridian and a hemianopic pupillary reaction of several months duration, the crossed bundles may show only a scattering of degenerated fibers indicating that the block is purely a physiological one. (3) In cases of longer duration, areas of degeneration, more marked on the cerebral than on the orbital side of the point of pressure, begin to show on sections and correspond with considerable definiteness to the fascicular distribution described by Henschen. (4) Even in long-standing cases of total blindness, with extreme pallor of the nerve head and loss of pupillary reaction, intact fibers are still histologically demonstrable on the retinal side of the point of pressure.

Their failure to be able to outline sharply the involved nerve tracts on their course through the optic nerve and chiasm led to a review of the literature on this subject. The majority of work that has been done was of an experimental nature on animals. But this does not necessarily mean that the tracts in man follow the same course as in the lower animals. Unfortunately the excellent work of Samuelsohn was omitted from their review, which contains an otherwise fairly complete bibliography. By a comparison of their own findings and those of other workers, the authors came to the following general conclusions:

(1) Despite the so-called atrophic pallor of the disks in patients having visual field defects resulting from lesions in the chiasmal regions, the histological examination of the nerves fails to show the expected degree of fiber degeneration unless the process has been of long duration. (2) The atrophy in the tracts considerably antedates that in the nerves where the fibers may be preserved by their retinal ganglion cells for several years after complete functional blindness has occurred. (3) In the presence of chiasmal pressure of long duration associated with sharply cut hemianopsias, even when to the ophthalmoscope the nerve shows the pallor of presumed atrophy, there may be no corresponding sharp delimitation of the areas of atrophy in the cross-sections of the nerve. (4) This at first sight would appear to be an inconsistency, but our more accurate perimetric findings with graded disks show that the boundaries of the seeing areas are less sharply cut than we had previously supposed, and perhaps correspond after all with the diffuse picture in the nerves.

Naffziger (*Ophthalmic Year-Book*, p. 241, 1916) in calling attention to the various forms of eye affections in association with head injuries, points to the frequent involvement of the optic nerve, rather than of the chiasm or the tracts, in fractures of the anterior fossa involving the orbital plate. The fracture extends into the optic foramen, and through the greater wing of the sphenoid. The anterior clinoid process is left as a free fragment held down only by its dural attachments. It is usually forced downward, compressing the nerve as it passes through the foramen. Following such an injury blindness is usually immediate and total. Unmistakable signs of primary optic atrophy appear in about two or three weeks. The possibility of elevating the depressed plate from the orbital side is suggested in the way of treatment for this condition. See, also, **Neurology of the eye.**

Optic atrophy, Hereditary. See **Leber's disease,** on p. 5841, Vol. VIII, as well as on p. 5154, Vol. VII of this *Encyclopedia*. See, also, under **Amblyopia, Central.**

Fisher also suggests that the casual agent in *Leber's disease* (q. v.) might be a disturbance of the pituitary body, of temporary duration and moderate in degree, implicating the visual pathway. If such a view is correct organo-therapy might be expected to do good. During pregnancy the pituitary gland may be enlarged to two or three times the normal, and a milky secretion can often be squeezed out of it. There is known to be a close relationship between the pituitary and sexual glands. Moreover, the pituitary and the optic chiasm are in such close contiguity that any small swelling of the former may extend to and make itself felt in the latter. In an 11 year old girl suffering from this form of optic atrophy, a Roentgen-ray examination of the sella turcica revealed something never seen before, and with which the Roentgen-ray officers were also quite unfamiliar. The sella turcica was not enlarged and its outline not distorted, but the depression was filled in with something which gave a cellular, or honey-comb like, shadow. The same appearance was exactly repeated in a further skiagraph taken two weeks later, and again a month later. Two girls and a boy about the same age were used as controls, and in none of them was any similar appearance found. The cause of this unusual appearance must be either in the substance or on the surface of the pituitary body. From these observations Fisher believes that in time it will be proved that Leber's hereditary optic atrophy is primarily due to an inherited temporary disorder of the pituitary body. So far as visual symptoms are concerned Leber's disease is progressive up to a certain point, and then comes to rest. If the lesion which gives rise to these symptoms

is due to some disorder of the pituitary body, it also must be temporary and transient, hence in an active and recent case of Leber's disease it might be of great help to have an early Roentgen-ray examination of the sella turcica.

Optic axis. 1. In *optics*, a straight line which passes through the geometrical and optical centers of a spheric reflecting or refracting surface, a mirror, lens, or centered optical system. See also **Axis.**

2. In *physiologic optics*, a straight line passing through the centers of the pupil and crystalline lens.

Optic canal. Optic foramen.

Optic capsule. In comparative anatomy, a cartilaginous or osseous structure which represents the sclerotic coat of the human eye.

Optic center. OPTICAL CENTER. In *optics*, a point upon the axis of a lens, generally so situated within it that every ray passing through the lens connects the surface-points of those incident and emergent rays which are in themselves coincident, or parallel to each other on opposite sides of the lens. In a double-convex or double-concave lens the optic center lies within the lens; in a plano-convex or plano-concave lens, it is the point where the convex surface of the lens is pierced by the axis; in the meniscus and contrameniscus it is outside of the lens, beyond the surface that is more accutely curved. If the thickness of the lens is small compared with its focal length, the dimensions of the object and image are very nearly proportional to their distances from the optic center, which is then a point midway between the poles of the surfaces.—(C. F. P.)

Optic centers, Injuries of the. See **Injuries of the eye,** as well as under **Military ophthalmology,** on p. 7706, Vol. X of this *Encyclopedia.*

Optic chiasm. See p. 2039, Vol. III of this *Encyclopedia.*

Optic commissure. Optic chiasm.

Optic cups. In comparative anatomy, cup-shaped or bell-shaped depressions lined with epithelial cells, usually also provided with pigment cells and connected with a nervous filament; they subserve vision.

Optic disc. OPTIC-NERVE ENTRANCE. OPTIC PAPILLA. NERVE HEAD. HEAD OF THE OPTIC NERVE. BLIND SPOT. The termination of the optic nerve as it pierces the eyeball and spreads out to form the inner layer of the retina. Normally the optic disc is nearly circular in outline, averaging about 1.5 mm. in diameter. After death it is of a whitish color, but in life of a pinkish or reddish tint, and, on careful examination, is seen to be composed of several differently colored zones. (1) A central clear spot, the funnel-like depression from which emerges the central retinal vessel. (2) A vascular zone containing

many capillaries. (3) A narrow, light band, the connective-tissue ring. (4) Surrounding all, the darker choroidal zone. According to Merkel, the optic disc is flat with a central depression or excavation, and not papilliform, as the synonym optic papilla would signify. (Foster.) See **Anatomy of the eye**; also, the section on **Histology of the eye,** and **Optic nerve**; as well as **Fundus.**

Optic foramen. The opening at the apex of the orbit, the anterior termination of the optic groove, for the passage, from the cavity of the skull into the orbit, of the optic nerve and ophthalmic artery. It lies in the sphenoid bone just beneath the lesser wing.

Optic ganglion. OPHTHALMIC GANGLION. A small, quadrangular ganglion situated between the optic nerve and the external rectus muscle. See, also, p. 5344, Vol VII of this *Encyclopedia.*

Optic groove. The shallow groove upon the upper surface of the body of the sphenoid bone, in front of the dorsum sellæ and terminating anteriorly in the optic foramina. The optic chiasma rests in it.

Optic hyperesthesia. Morbidly developed sensitiveness of the eye.

Optician. One versed in the science of optics; one who makes or deals in optical instruments; one versed in the optical considerations of the eye, and capable of diagnosing and correcting its errors of refraction; a refractionist. See, also, **Eyeglasses, History of,** p. 4894, Vol. VII of this *Encyclopedia.*

Opticist. A person skilled in the science of optics.

Optic nerve. The special nerve of human eyesight is to a large extent described and depicted in several sections of this *Encyclopedia,* notably on page 395, Vol. I; p. 5965, Vol. VIII. and on p. 6547, Vol. IX of this *Encyclopedia.* The comparative anatomy and physiology of the organ is treated under **Comparative ophthalmology,** in particular on p. 2734, Vol. IV of this work.

Behr (von Graefe's *Arch. f. Ophth.*, 29, p. 1) has proved by anatomical examinations and injections of Prussian-blue into the human optic nerve, that intimate connections exist between the system of glia fibres and axis cylinders. From coarser glia fibres fine filaments branch off, penetrate the medullary sheaths, and immediately go to the axis cylinders. The whole ectodermal neuroglious tissue is separated from the vascular mesodermal septal tissue by a glious limitant membrane, into which the glia fibres radiate with a funnel-shaped foot. A third connection exists with the glia cells. From these anatomical findings it is probable that an essential task of the glia fibres is to carry from the septal tissue the dissolved nutritive material directly to the working axis clyinders. This is further supported by injections of India-ink into the optic nerve of the living dog. The migration of India-

ink shows, that a central current of fluid from the globe exists in the optic nerve, confined to the system of glia fibres. Hence the glious tissue plays the most important part in the nutrition of the nervous substance, so that it may be called the lymphatic system of the nervous substance.

Besides the fixed glia cells another kind exists with ameboid and phagocytic properties, which transmigrate the tissue and collect the particles of India-ink and at the periphery of the nervous bundle discharge them directly into the blood vessels. They are propagated by amitotic partition. Functionally the leucocytes of the mesodermal and entodermal tissues and the movable glia cells of the ectodermal nervous tissue are of the same order.

G. F. C. Wallis (*Practitioner*, p. 41, Jan., 1917) has also made some anatomic studies of the chiasma, in eleven cases, the method followed being to remove the calvarium and then dissect away the brain piecemeal. In no case did the chiasma rest wholly upon the optic groove. In one case rather more than half of it rested upon the optic groove and olivary eminence, the posterior part lying on the pituitary body, and in another it was far enough forward just to touch the olivary eminence. The author concludes that while the chiasma does occasionally lie upon the optic sulcus, it is nearly always completely posterior to it. The chiasm measured from 7 mm. to 11 mm. anteroposteriorly and about 3 mm. less laterally, so that at most only a small part of it could ever lie upon the optic groove. The intracranial part of the optic nerves was found to vary between 7 mm. and 12 mm. in length, and the angle formed by their junction became more acute, the more posterior the situation of the chiasma. When the latter was relatively far forward the angle became U-shaped or even like a bent bow. Several other points are discussed, such as the extent of the bony surface between the limbus sphenoidalis and the anterior margin of the sella turcica, the antero-posterior measurement of the latter, the length of the optic canals, and the extent and condition of the sphenoidal sinus. A relationship, which is of interest to ophthalmologists, namely the height at which the chiasma is suspended above the diaphragma sellæ, is unfortunately not mentioned; indeed, the reader is led to believe that the chiasma normally, to some extent, rests upon the pituitary. This is contrary to the findings of other observers. It is probably impossible to ascertain this point with accuracy by removing the brain from above, and no doubt it was omitted on this account.

Optic nerve, Abscess of the. Harry S. Gradle (*Annals of Ophthalmology*, July, 1915) reports an example of this exceedingly rare condi-

tion. It resulted directly from a suppurating carcinoma that filled the nose. The dura was first attacked in the intracanalicular portion and drawn into the abscess, following which the abscess attacked the optic nerve proper. The pus burrowed anteriorly and posteriorly in a conical form. Anteriorly the globe was not reached, while posteriorly there seemed to be less resistance and the abscess involved the chiasm.

Apart from the rare clinical and still rarer histologic findings the case is of interest in that it throws light on the scotomata and blindness secondary to accessory sinus disease.

Optic nerve, Absence of. APLASIA OF THE OPTIC NERVE. See p. 2935, Vol. IV of this *Encyclopedia*.

Optic nerve, Anomalies of. See p. 2932, Vol. IV of this *Encyclopedia*.

To this account of the subject may be added one of numerous other anomalies.

At the autopsy of a man, aged 66, who died from cirrhosis of the liver and nephritis, but had not been examined ophthalmoscopically, the following anomaly of the right optic nerve was accidentally found by C. M. Sneed (*Arch. für Augenheilk*, p. 117, Vol. 76). In front of the chiasm the optic nerve was separated into two parts for a length of about 6 mm., the temporal half being about 2.5 mm. thick, the nasal about 4 mm. Toward the eyeball both were reunited. The sections of the hardened nerve showed that both parts were separated by connective tissue for about 6 mm. and at the complete separation each had its own sheath of connective tissue. Both optic tracts were perfectly normal. Literature contains only three similar cases, in which with the greatest probability the isolated fascicle indicated the anatomic course of the noncrossed optic fibres. This could not be ascertained in the above mentioned case.

Optic nerve, Aplasia of the. See **Optic nerve, Absence of the.**

Optic nerve, Apoplexy of. See p. 5806, Vol. VIII of this *Encyclopedia;* as well as **Optic nerve, Hemorrhage into the.**

Optic nerve, Atrophy of the. See **Optic atrophy.**

Optic nerve, Avulsion of the. A. N. Natanson (*Rusky Vratch*, 6 and 7, 1912) gives an account of this rare accident and says that it is the 16th case recorded in the literature of the subject and the third in Russia. Two weeks before Natanson saw the patient he had slipped and struck his eye with the tip of a thin stick he was carrying. Some days later when the swelling had subsided, the patient found that the eye was completely blind. When first seen, both eyelids showed remains of subcutaneous hemorrhages, as also subconjunctival ones particularly at the nasal side, in which situation there was a small scar in the conjunctiva. There was no light perception and the pupil was dilated and

immobile. The media were clear, but instead of the optic disc there was a hole 9 mm. deep surrounded by the white sclerotic ring, around which for some little distance the retina had disappeared. This part of the fundus was sown with hemorrhages from the torn retinal vessels, while the central part of the retina presented the opalescent appearance seen in embolism of the central artery.

The mechanism of the injury is probably explained in the same way as in the cases of Aschmann, and Liebreicht and Reis, in which an anatomical examination was made. The tip of the stick after penetrating the orbit violently stretched the optic nerve backwards while pressing the eye forwards. In consequence of this strain the nerve gave way at its attachment to the sclerotic ring.

See, also, **Injuries of the eye**; as well as p. 719, Vol. I, and p. 4563, Vol. VI, of this *Encyclopedia.*

Optic nerve, Colloid bodies in the. See p. 2327, Vol. IV of this *Encyclopedia.*

Optic nerve, Coloboma of. See p. 2902, Vol. IV of this *Encyclopedia.*

Optic nerve, Congenital defects of. See p. 2931, Vol. IV of this *Encyclopedia.*

Optic nerve, Cylindroma of the. See p. 3659, Vol. V of this *Encyclopedia.*

To these observations may be added De Obarrio's case (*Ophthalmic Year-Book*, p. 326, 1913) the eye was retained with vision of 20/50 and excellent motility, after removal of a tumor 5x3½x2½ cm. through an incision along the upper orbital margin, was retained. The tumor lay horizontally from before backward in the orbital vault, with four-fifths of its bulk posterior to the equator of the eyeball. Its principal features were a myxomatous degeneration of the stroma, large cells apparently of endothelial origin, and marked tendency of the cellular elements to form cylindric lymphatic channels. On these grounds the writer gives his tumor the title of cylindroma.

Optic nerve, Cyst of. This is an extremely rare condition, almost always associated with persistent hyaloid artery and other congenital malformations (colobomata, etc.) of the parts in the ocular fundus.

Optic nerve, Development of. See p. 3902, Vol. V of this *Encyclopedia.*

Optic nerve, Diseases of the. This subject is extensively considered under numerous captions of this *Encyclopedia*, especially **Atrophy of the optic nerve**; **Neurology of the eye**; **Choked disc**; **Syphilis of the eye**; **Optic neuritis**; **Toxic amblyopia**; **Optic nerve atrophy**; **Brain tumor,** and similar captions.

To the matter found under these headings may be here added a few observations.

The importance of carefully considering not only the ophthalmoscopic appearance of the nerve-head but the functions of the nerve as tested for acuity of central and peripheral vision and color perception, is noted by Friedenwald (*Prac. Med. Series,* Eye, p. 111, 1909). Changes during the progress of the disease as well as the connection of these data with the previous history and habits of the patient, and with such other ocular constitutional, organic, and especially nervous diseases as may be discovered, should also be considered. Descending neuritis with the picture of choked disc is generally due to brain tumor. It is bi-lateral except in rare cases of tumor in the middle fossa. There is at first little or no visual disturbance, central vision is unimpaired, and the enlargement of the blind spot is easily overlooked. Complete transient obstruction of vision is, however, a frequent and characteristic symptom. Atrophy develops late, causing rapid and marked loss of sight. Other causes are cerebral abscess, serous meningitis, hydrocephalus, nephritis and anemia, and unilateral choked disc may be due to orbital causes or meningeal syphilis descending along the nerve sheath. Spontaneous recovery is rare except in children or when due to hemorrhage or to syphilis. In descending neuritis with slight swelling or changes in the vessels, but with exudate veiling the contour of the disc, vision drops rapidly. Bilateral forms are usually due to meningitis, especially the tubercular or syphilitic basal type. The epidemic form causes neuritis in 16 per cent. of the cases. It may result from nephritis, and frequently leads to post-neuritic atrophy. In atrophy it may be difficult to distinguish between simple and post-neuritic forms. The former is generally of spinal origin, beginning at the bulbar end of the nerve. Disc pallor and visual disturbance occur simultaneously.

In one form there is marked diminution of vision throughout the entire field, with marked contraction of the color fields. Deterioration is rapid, hastened by mercury, and prognosis is absolutely bad. A second class is characterized by sector-shaped defects in the field of vision, with normal function, at least for quite a time, in the remaining portion, closely resembling retrobulbar perineuritis with secondary atrophy of the disc. A third variety shows concentric contraction of the field with good central vision and good color-vision in the portion preserved. Similar fields are found in syphilitic disease of the intracranial portion of the optic nerve. The last two classes are benefited by mercury. True primary optic atrophy never occurs in cerebral syphilis, not, in all probability, in spinal syphilis, and is practically excluded by the presence of a central scotoma. Limitation to one eye, variations in visual function, complication with other cerebral nerve

palsies, Argyll-Robertson pupil, and hemiopic defects, all speak in favor of a secondary atrophy due to syphilis. This form may also be caused by pressure on the nerve by tumor, rigid carotids or by embolism and thrombosis, as well as by retinal or choroidal disease, and by injury of the nerve in the optic canal, either directly or by indirect violence. Normal discs may be found in acute or chronic forms of retrobulbar neuritis. The alcohol-tobacco toxic type is the most common, with a long but narrow paracentral scotoma, reaching from the point of fixation to Mariotte's blind spot. The course is generally very slow, and great improvement or even recovery is possible. There is usually pallor of the temporal half of the disc. In poisoning from quinin, salicylic acid, methyl alcohol and other drugs, there is marked contraction of the blood vessels and early blindness. Lead poisoning produces papillitis, with marked vascular changes. Accessory sinus disease, influenza, syphilis, menstrual disturbances, rheumatism, are also factors.

It may be said of Friedenwald's paper that notwithstanding the well known value of the perimeter in dealing with all affections of the optic nerve, one sometimes asks himself whether it is used with that frequency and persistency without which no definite information can be obtained. The trouble with this means of examination is mainly that it absorbs considerable time, requires a good deal of patience and is generally useless unless the fields are carefully measured and compared from time to time.

A classic contribution to the *histology and pathology of optic lesions* is the essay of Marcus Gunn (*Ophthalmology*, Jan., 1907). He enumerates the channels through which the nerve may be affected as follows:

1. From its developmental history and from its structure the optic nerve is to be regarded as forming part of the central nervous system.

2. The optic nerve, throughout its entire extra-cranial course, is enveloped by sheaths which are a direct prolongation of the meninges, and the spaces between these sheaths are continuous with the spaces between the meninges of the brain. The wider and more important of these intervaginal spaces of the nerve is the subarachnoid, because the subarachnoid space of the brain, with which it is in direct relation, contains a relatively large amount of the cerebro-spinal fluid, and is again in direct communication with the cerebral ventricular system through the foramina of Magendie and of Key and Retzius. This continuity between the sheaths, sheath-spaces and contained fluid of the brain and optic nerves is of pathological importance, as explaining the

possibility of a direct transmission of disease from brain to nerve, or *vice versa.*

3. Their position at the base of the brain renders the intracranial optic nerves, with their commissure and tracts, prone to suffer in inflammation of the basal meninges, and liable to be damaged by direct pressure of new growth, aneurism, or a distended third ventricle. It is sufficient to give bare mention to this cause of optic nerve disease here; the causation is obvious, and examples are not infrequent.

4. After its entrance into the optic canal, the nerve has, for the rest of its course, all the exposures of a peripheral nerve. Thus, while still in the optic canal, the nerve may be pressed upon unduly by a diseased ophthalmic artery; may be involved in a syphilitic affection of the bone or its covering; may suffer through the thin inner wall of the canal from an altered sphenoidal sinus; or may be injured in fracture of the base of the skull. It is important to remember that in this intra-canalicular part of its course the dural sheath is intimately adherent to the bone, and is also closely applied to the pial sheath and optic nerve trunk, though not so intimately as to prevent all passage of fluid along the subarachnoid space. This is an important fixed area, preventing the nerve from being displaced either way when pulled upon.

In the orbit the nerve may be inflamed along with the other tissues in an orbital cellulitis; it may be implicated through rheumatic or other affections of its sheaths; may be injured in orbital wounds, or may undergo atrophy from pressure exerted upon it by tumors or by hemorrhage into the inter-vaginal space surrounding it. At its termination in the papilla, the nerve may suffer in a peri-papillitic choroidal atrophy by a cutting-off of the main part of its local blood supply, or may become affected by a continued supernormal intra-ocular tension. In its passage through the scleral aperture, the nerve fibers are liable to strangulation by the tight meshwork of the lamina cribrosa; this may occur in any form of swelling of the nerve trunk, or in an altered thickened state of the fibrous tissue framework.

5. The optic nerve fibers may degenerate secondary to destruction or impaired nutrition of their ganglion cells in the retina. (a) These ganglion cells may suffer (a) along with other retinal structures in atrophy of the retina following total embolism or thrombosis of the arteria centralis; in pigmentary degeneration of the retina—primary or secondary; or in retinal detachment. (b) In some forms of poisoning, as e. g., from nicotine and bisulphide of carbon. (c) From an inherited neuropathy. Under this heading may be included the

changes in amaurotic family idiocy, cerebral diplegia and possibly Gowers's so-called abiotrophy.

6. The optic nerve may suffer from an extension of an ocular inflammation.

7. Lastly, the optic nerve may, like other parts of the body, suffer from a general influence produced by serious disease, as e. g., in renal disease, syphilis, tuberculosis, severe anemia, and rarely in acute febrile diseases.

Optic nerve, Edema of the. See **Choked disc**; and **Optic neuritis.**

Optic nerve, Endothelioma of the. See p. 4312, Vol. VI of this *Encyclopedia.*

Optic nerve, Excavation of the. The normal pit in the optic disk has many times been referred to (see, *e. g.*, **Anatomy of the eye**) in this *Encyclopedia.* Generally speaking, obeservers recognize at least two forms of pathologic excavation, one due to some variety of optic atrophy, the other to glaucoma. Schnabel (*Practical Med. Series; Eye*, p. 164, 1909) believes, however, that of the many thousand cases of atrophy of the optic nerve seen by him, which had no glaucoma, not one showed an ophthalmoscopically noticeable pathologic excavation. Every pathologic excavation which is seen ophthalmoscopically is glaucomatous. In many optic nerves with glaucomatous excavations. examined ophthalmoscopically or anatomically, or both, by Schnabel, the lamina cribrosa was in its normal position. The pressure excavation is only imaginary. The only actually existing pathologic excavation, the glaucomatous excavation, is produced by a special form of disappearance of nerve fibers, and therefore is an atrophic excavation.

Optic nerve, Fibroma of. See p. 5187, Vol. VII of this *Encyclopedia.*

Optic nerve, Glioma of the. See p. 5580, Vol. VII of this *Encyclopedia.*

Optic nerve, Gumma of the. See p. 5660, Vol. VII of this *Encyclopedia.*

Optic nerve-head. See p. 4031, Vol. VI of this *Encyclopedia;* also **Anatomy of the eye.**

Optic nerve, Hemorrhage into the. See **Optic nerve, Apoplexy of the.**

A good account is also given of this subject by Dupuy-Dutemps (*Annales d' Oculistique*, Vol. 151, March, 1914) of which an excellent abstract by W. C. Souter appears in the *Ophthalmic Review* for October, 1914.

Hitherto there has been a deal of misinterpretation and confusion, chiefly with cases of hemorrhage into the nerve trunk itself, and Dupuy-Dutemps asks for the rejection of the classical signs, viz., the retinal ischemia, which, he says, belongs solely to thrombosis and embolism of the central artery; the delayed peripapillary hemorrhage which, he says, arises only from interstitial nerve hemorrhage, e. g.,

from laceration of the nerve trunk; and the secondary pigmentation around the, usually atrophic, disc which as fixed, persistent pigment is, he says, not proved to result from retinal hemorrhage but is most likely either preexistent or due to circulatory disturbances in choroid and retina. These three signs have never been found in pure cases anatomically examined.

Unilateral spontaneous sheath hemorrhage, often diagnosed clinically as a cause of sudden blindness, has never been verified. Hematoma of the sheath, apart from direct trauma complicated with wound of the nerve-trunk itself, has always been consecutive to meningeal hemorrhage, either traumatic or spontaneous, and the only physical signs are—congestion of the disc with edema more or less marked; dilatation of the veins; retinal hemorrhages, variable in number and extent, arising from vascular ruptures in retina; vitreous hemorrhages exceptionally.

These signs appear early, as a result of venous stasis from pressure on the central vein as it crosses the sheath cavity after leaving the nerve. Where the tension of the extravasated blood is insufficient to impede the return circulation in the vein there may be no fundus change, whereas in severe arterial bleedings marked fundus changes may be expected. In some rare cases fundus changes have been present only in one eye, the other nerve-sheath having been found at autopsy to be isolated from the cranial subarachnoid spaces by adhesions at the optic foramen.

Initial papillary stasis has to be distinguished from the later stasis due to meningeal changes causing hydrocephalus weeks or months after the trauma.

Dupuy-Dutemps finds support here for his views on cerebral tumor stasis, the different pictures being due to the slow, progressive and persistent cerebral tumor pressure as compared with the sudden, perhaps, absolute, arrest of the return circulation leading to more hemorrhages and less edema in sheath cases. Quite a marked papilledema can occur in some hours.

An examination of the fundus in cases of meningeal hemorrhage will, therefore, be useful even before one has had recourse to the still more useful lumbar puncture and will thus furnish an early indication for the performance of the occasionally remarkably successful cerebral decompression.

Anatomical, physiological and experimental investigations all support the view that there is no passage forwards to choroid, retina or vitreous from the anterior end of the sheath cavity, nor from the sheath cavity into the pial coat or the nerve trunk which it surrounds.

In the author's first case, however, blood was found in the connective tissue surrounding the central vessels and even in their adventitia as, side by side, they crossed the sheath cavity, and even around them after they had got quite beyond the dura mater.

Although Dupuy-Dutemps' longitudinal section of the nerve in the first case shows no free blood around the central vessel in the nerve, it is perhaps not too much to expect that, after some longer interval than the thirteen hours of that case, some blood might find its way down around the central vessels and appear later as a secondary ecchymosis of the disc.

Optic nerve, Hereditary diseases of the. See **Heredity in ophthalmology**; as well as **Familial diseases.**

Optic nerve, Hyalin bodies in the. See p. 2328, Vol. IV of this *Encyclopedia.*

Optic nerve, Hydatids of the. Parsons (*Pathology of the Eye,* Vol. II, pt. 2, p. 693) mentions this tumor as among the rarest of the new growths affecting the optic nerve.

Optic nerve, Injuries of the. See **Injuries of the eye**; as well as **Avulsion of the optic nerve,** and **Military surgery of the eye.**

In addition to the matter furnished under these captions the essay of de Kleijn and Nieuwenhuyse (*Graefe's Archiv.,* Vol. 82, pt. 1) abstracted by W. C. Souter is of value. They report five cases with fracture of orbital roof and base of skull—in one the field enlargement was for colors only, in another for white and colors, and in a third there was a combination of central scotoma with enlargement of the blind spot. Pure cases in which only an enlargement of the blind spot or a central scotoma exists, are only rarely met with in actual base fractures. Fundus changes met with in cases seen years after the accident may have resulted at the time of the accident or merely come on later, possibly by callus formation. Blood extravasated may immediately after the accident narrow the optic canal and lead to enlarged blind spot and even central scotoma, even where the optic foramen has not been fractured.

Secondly they discuss white disc after fracture of the base of the skull, a condition usually arising from a fracture of the optic foramen, and they give notes of one case to show the islands in the field.

Thirdly they deal with cases of basal fracture in which without fundus change there is contraction of the fields. Here functional disease might be the cause, so to eliminate that, the different meridians were done more than once, the whole examination was repeated, and cases that showed any other signs of functional disease were rejected for the purposes of this section.

The authors conclude from these cases that after skull injuries field contractions—without fundus changes, and not of a functional nature—for white and colors, can be found. Several of their cases had been diagnosed in other departments as functional because of the much contracted fields with normal fundi and the absence of organic signs, but the authors object to this view. They think that if by repeated examinations the perimetric limits of the fields are constant, we must not conclude that there is hysteria merely because no organic changes in the fundi are found. In doubtful cases the occurrence of such paralyses strongly suggests the existence of true organic changes, while contracted color fields in hysteria and in socalled traumatic neuroses may really be due to some labyrinthine affection. In no case did they find contraction of fields with normal fundi in which the labyrinth was intact.

Notes of two cases are given to show that even in labyrinth injuries, however, there may be no contraction of the fields. Whether labyrinth affections can have any influence on the size of the blind spot also they are not prepared to say. Up to date they had not seen a single case of pure labyrinth affection with enlargement of the blind spot.

Their conclusions then are, first, that after skull injuries there may be found in many cases an enlargement of the blind spot; second, that likewise contractions of the fields, not of a functional nature, may be found in normal fundi; third, that if these contractions are to be correlated with labyrinth affections cases of purely labyrinthine disease must be examined ad hoc; and fourth, the precise determination of the size of the blind spot and of the peripheral field for white and colors in old skull injuries is in doubtful cases never to be omitted.

As an appendix notes are given of two cases, one of optic nerve injury in a normal birth and normal pelvis, the other of double pulsating exophthalmos after injury.

Optic nerve, Intradural tumors of. Parsons (*Pathology*, II, 2, p. 693) has collected accounts of 18 primary tumors originating within the nerve-sheath (extraneural or intradural), as opposed to 102 instances developing in the nerve substance (intraneural).

de Schweinitz (*Annals of Ophthal.*, Apr., 1912, p. 393) has described a patient with primary intradural tumor of the right optic nerve. A boy, twelve years old at the time of operation, presented nothing of importance in his family history, but when he was between his third and fourth years had suffered from convulsions; one convulsion also occurred in his sixth year. Exophthalmos was first noted when the child was about five years of age, and gradually increased, with progressive atrophy of the optic nerve without preceding neuritis or choking

of the disc. X-ray examination indicated absorption of bone or bulging of the walls of the orbit outward, but nothing else. The eyeball was displaced forward and downward, and Hertel's instrument recorded 30 mm. At the operation a neoplasm, not unlike the shape of the eyeball itself, was found growing from the optic nerve, with a small portion of uninvolved nerve between the anterior part of the growth and the posterior portion of the eyeball. The growth was dark-red in color, entirely encapsulated, 3.5 cm. in length, 2.5 cm. in width, and 3 cm. in depth. On section it was seen that the tumor proceeded from the nerve in a fan-shaped area and was entirely covered by a dural capsule. It was composed, in general terms, of a connective tissue, through which were scattered numerous nuclei, together with swollen and edematous nerve fibrils. In some of the sections cells exactly like ganglion cells were present. A neurogliar hyperplasia was not demonstrable. Either the growth had begun in very early life, or more probably it was congenital.

Seven months after operation, at the time of report, there had been no recurrence, nor were there any signs of intracranial involvement.

In discussion Langdon stated that in the *Transactions of the Ophthalmological Society of the United Kingdom* there were reported four cases of optic nerve tumors, three by Hill Griffith, one extradural and two intradural, and an extradural one by Arthur Benson. In opening the discussion of the former paper, the president, Berry, expressed his surprise at the possibility of there being such a division as intra- and extra-dural tumors of the optic nerve, apparently not considering the dura as part of the nerve. Collins and Herbert Parsons both said the division was a proper one, inasmuch as some growths sprang from the outer layers of the dura itself. Parsons referred to Byers' paper and agreed with him and Collins that nearly all the intradural tumors were a form of fibrous growth, which he called "fibromatosis," even though they were reported under such titles as myxomata, gliomyxomata, sarcomata, and myxosarcomata; of the 18 extradural growths that have been reported, nearly all were endotheliomata, as was the case reported in the same volume by Benson.

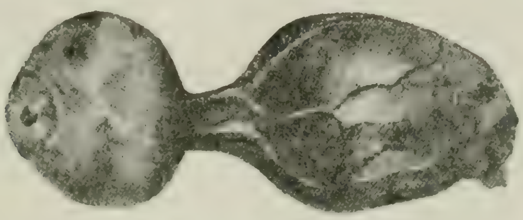
Sweet found upon operation an intradural tumor presenting the same appearance as that shown by de Schweinitz. The tumor began at the optic nerve, 7 mm. back of the globe, and measured 39 mm. long and 25 mm. at its greater curvature. The exact character of the tumor had not as yet been definitely determined.

Heed (*Trans. Am. Ophthal. Society*, Vol. XIV, Part i, 1915, p. 331) also gives the history of a case in a girl, aged ten years, whose left eye was noticed to be prominent almost coincidently with vaccina-

tion. In four months the eye had become very prominent, and sight was reduced to perception of light. The protrusion of the eyeball slowly increased, despite treatment carried out with mercury and iodides for a period of six months.

When examined by Heed, twelve months after the onset, the left eyeball was thrust forward approximately 2 cm., and the summit of the cornea was directed down and in. Rotation was limited externally and absent in an upward direction. V. = no p.l. Palpation failed to discover any growth in the orbit. Posterior synechiæ. Optic disc greyish-white.

As to treatment, after an external canthotomy had been performed, a tumor was found to extend from the globe well back to the optic foramen. The tumor, together with the eyeball, was enucleated. The



Intradural Tumor. (Heed.)

appearances of the tumor are shown in the accompanying figure. It was a spindle-shaped mass of dark-red color, measuring 35 mm. in length and 26 mm. at its point of greatest thickness. Its capsule was formed by the dura. It was believed that the tumor in this case might properly be classed as an endothelioma.

Heed points out that his case agrees in history, symptoms, and general characteristics with the majority of those already reported—early age of patient, absence of pain, no injury, slow development of the proptosis, good health of the patient, presence of a post-neuritic atrophy, and, lastly, the inability to palpate any orbital growth.

See, also, p. 6552, Vol. IX, as well as **Fibromatosis,** p. 5187, Vol. VII of this *Encyclopedia.*

Optic nerve, Laceration of. See **Optic nerve, Injuries of the.**

Optic nerve, Lacunar atrophy of the. CAVERNOUS ATROPHY OF THE OPTIC NERVE. Stock (*Ophthalmic Year-Book*, p. 262, 1909) believes this condition to be due to the traction of the nerve fibers, which, on account of their greater size back of the lamina cribrosa, cannot be drawn for-

ward through it, and give way leaving spaces that form the cavities in the nerve. The more gradual process of atrophy of the nerve tissue permits the glia to replace the tissue removed, so that these spaces are found only in glaucoma and high myopia, where the fibers are subjected to traction. The view of Küschel that traction on the nerve fibers is the common cause of impairment of the visual field in choked disc and glaucoma has been referred to in connection with the latter condition. See, also, p. 1794, Vol. III, as well as p. 6990, Vol. IX of this *Encyclopedia.*

Optic nerve, Myxoma of the. Semimalignant tumors, composed in part or entirely (rare) of mucous tissue, occasionally attack the optic nerve. See p. 8280, Vol. XI of this *Encyclopedia.*

Optic nerve, Operations on the. Optico-ciliary neurotomy and neurectomy as a substitute for enucleation will be found described on p. 4456, Vol. VI of this *Encyclopedia.* Excision of the nerve as a part of tumor extirpation is treated under **Krönlein's operation.**

Optic nerve, Ossification of the. This rare occurrence is described by, among others, Demaria (*Ophthalmic Year-Book*, p. 243, 1916). He reports the microscopic findings of an eye removed from a woman of 70 years. There had been a chronic iridocyclitis with subsequent atrophy and ossification. The bony tissue which replaced the choroid, instead of terminating in a bony ring in the vicinity of the optic disc, extended as a ring into the structure of the disc itself. The bony structure was typical, containing a moderate quantity of medulla, Haversian canals and osteoblasts.

Optic nerve, Psammoma of. See **Psammoma** as well as **Tumors of the Eye.**

Optic nerve, Resection of. See **Krönlein's operation,** p. 6871, Vol. IX of this *Encyclopedia.*

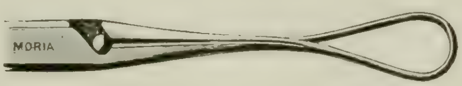
Optic nerve, Rupture of the. An account of this traumatism, apart from self mutillation of the insane, is rather rare. Krauss (*Münch. Med. Wochenschr.*, No. 23, 1913) reports such case in a man whose left eye was struck with a piece of wood weighing 400 grams. Immediately after the accident there was ecchymosis of the lids, subconjunctival hemorrhages, moderate exophthalmos and inactive pupil. Ophthalmoscopic examination revealed extensive preretinal and retinal hemorrhages, especially in the vicinity of the disc region. The disc itself could not be seen. There was loss of light perception.

After absorption had taken place, the indirect method revealed in the disc region a poorly defined, white oval with a grayish center. Vessels were visible only at the lower inner margin; in the cloudy vitreous a floating severed retinal vessel was discernible. There were

still hemorrhages at the upper inner disc margin, and at the upper margin chorioretinal changes. The ophthalmoscopic picture simulated coloboma of the optic nerve.

Optic nerve, Sarcoma of the. See **Sarcoma**; as well as **Tumors of the eye.** A typical example of one form of these occasional neoplasms is reported by W. Campbell Posey (*Practical Med. Series*, Eye, p. 159, 1912). The patient was a woman of 53. The early symptoms were largely nasal, followed by prominence of the left eye. Knapp's modification of Killian's operation was performed to eradicate any diseased accessory nasal sinuses. The operation had no influence upon the proptosis. Treatment with mercury and the iodids for two months proving unavailing, a Krönlein operation was performed. A tumor was discovered back of the eyeball along the course of the optic nerve. The eye and a large part of the orbital contents were removed. Healing was uneventful. The tumor was found to occupy the sheath of the optic nerve and upon examination was pronounced to be a small round-cell sarcoma. Three years elapsed without any signs of recurrence.

Optic nerve stretcher. De Wecker is the inventor of this instrument depicted in the text. It was intended to be passed through an open-



de Wecker's Double Hook for Stretching the Optic Nerve.

ing into the orbit and employed as a therapeutic agent in serious diseases of the nerve.

Optic nerve, Syphiloma of the. Syphilis of the orbital portion of the optic nerve is very rare. Uhthoff's work on ocular affections in syphilis of the brain does not contain a single case. According to him the optic nerve is very frequently affected in the form of a perineuritis as a partial phenomenon of a more or less general meningitis. Syphilis of the nerve itself generally attacks its intracranial or canalicular portions.

F. H. Verhoeff (*Pr. Med. Series*, Eye, p. 160, 1912) reports the clinical history of a woman, aged 55, who came on account of impairment of sight, 7 months after an eruption of the skin which she had had 13 months. Since that time she had been constantly under specific treatment. Both eyes showed fine opacities of the vitreous, papillitis,

syphilitic chorio-retinitis in the form of yellow-white patches, and a hemorrhage at the temporal side of the disc. Although she was treated with inunctions and iodid of potash generously, the opacities of the vitreous increased, and insidious iritis developed with intense pain. Five months after the first examination there was marked exophthalmos of the right eye with edema of the lids and conjunctiva, lack of motility and loss of vision. The examination of the nose was negative. At the enucleation five days later the optic nerve showed a tumor-like thickening which was diagnosed as syphiloma. Renewed treatment with mercury and iodid of potash improved the general condition and that of the left eye, so that the patient could be discharged four weeks after the operation.

The histologic changes are described in detail. More or less sharply defined choroidal foci, to which the retina was adherent, consisted of dense infiltration with lymphoid and plasma cells through the whole thickness of the choroid, and imbibition of the choro-capillaries with pus cells. The optic nerve, excepting the temporal portion of the lamina cribrosa, where the nerve bundles were replaced by proliferated glia, was completely necrotic. The central vessels were filled with necrotic thrombi; the periphery of the nerve contained numerous pus cells which towards the center were necrotic. The subvaginal space was extended by granulation tissue, infiltrated with plasma cells and pus cells. In sections, treated according to Levaditi, numerous spirochetæ were seen. Especially in the center they were crowded in dense convolutions, and also in the thrombotic central vessels.

Of similar cases in the literature this is the only one in which an early ophthalmoscopic examination could be made. The presence of opacities of the vitreous was especially important in the diagnosis, else the choked disc might have been attributed to a brain tumor.

Optic nerve, Tubercle of the. A good account of this rather unusual condition (solitary tubercle) is given by Jacobs (*Annals of Ophthal.*, p. 141, Jan., 1913) which he studied microscopically. The patient had a tumor of the head of the optic nerve which had encroached on the nerve and retina. The writer points out, as Axenfeld and Verderame had previously done, that however justifiable a so-called expectant or waiting therapy may be in solitary tubercle of the eyeball, when not complicated by rupture of the bulb or severe secondary symptoms, in solitary tubercles close to or in the optic disc, the danger of an ascending process places such cases in a class which should be differently treated. With the destruction of central vision or marked decrease in the visual field Jacob thinks enucleation is in order.

The same patient was successfully treated with lactic acid, as recommended by Axenfeld for tuberculosis of the conjunctiva. Retinal strands similar to those described by Imre were found during the study of the sections, and seemed to lend weight to the theory of a transition from pigment epithelium to connective tissue, or tissue staining like the latter.

Optic nerve, Tumors of the. OPTIC NEOPLASMS IN GENERAL. See also **Intradural tumors**; as well as **Fibromatosis** and **Tumors of the eye.**

A. C. Hudson (*Royal Lon. Ophthal. Hosp. Reports*, Vol. XVIII, Part iii, p. 317, 1917) has written an elaborate paper on primary tumors of the optic nerve for the purpose of making a fresh classification of this group of tumors, based on a critical examination of records of cases, and especially of the histological features. The groups are as follows:—

(1) A degenerative gliomatosis, implying a generalized overgrowth of neuroglial tissue, of infiltrative character, dependent on some degenerative change in the tissue of unknown etiology. These are found chiefly in the young, are of slow growth, and may not involve the anterior part of the optic nerve, and in many instances have intracranial extensions. The growth occurs within the dural sheath, affecting the pial sheath and the nerve; there are certain typical cells, and often a mucinous material between them, and sometimes a fibrillated material. Defect of vision generally precedes exophthalmos, which is of slow development, and mostly in the direction of the axis of the orbit. Movement of the eye is most often only slightly limited, but may be abolished. The optic disc may show papilledema or postneuritic atrophy, and the visual defect may be out of all proportion to the ophthalmic signs. Intracranial growth may be very slow, and not give rise to severe symptoms; the patient may succumb to some other illness. Removal after division of the external canthus is advocated rather than by Krönlein's operation, and local recurrence is unknown.

(2) Fibromatosis of the nerve sheath. The marked feature in this set is the large development of fibrous tissue. These also appear early in life, and are of slow growth; exophthalmos precedes visual defect, and the fundus change suggests obstruction of retinal circulation, followed by atrophy of the nerve.

(3) Endothelial tumor of the nerve sheath. This resembles the endothelial tumor of the cerebral meninges, with whorled arrangement of cells and central laminated concretions. The growth may form a cup, in which the globe rests. The arachnoid endothelial cells are probably the origin of some of these growths, although, in the opinion

of some, they may also arise in the dura. These tumors appear later in life than those of the previous groups, failure of sight is secondary to tumor formation, exophthalmos having existed without alteration in vision. The rate of growth is slow, protrusion is often down and out; movement is, as a rule, limited, as the anterior part of the nerve may be affected; the fundus shows vascular obstruction and nerve atrophy. Extension may occur into neighboring parts and the cranium. Local recurrence is not frequent after operation, and it is probably advisable to remove the globe.

Weeks (*Text-Book*, p. 522) gives the following list of optic tumors: *carcinoma* (metastatic); *hydatid cyst; endothelioma; fibroma; lymphangiectatic fibroma; glioma; gumma; myxoma; myxofibroma; psammoma; sarcoma; tubercle;* and, finally, most of the varieties of *mixed sarcoma,* i. e., angio-, alveolar, endothelial, fibro-, glio-, metastatic, myxo-. Of these myxosarcoma is the most frequent, 12 to 15 per cent.; all the forms of sarcoma totalling 33 per cent.

The *duration* of these neoplasms depends partly on their histologic character. Finlay, of 50 cases, finds the mean time for glioma one and a half years; sarcoma 3.47 years; fibroma 5.2 years.

In the *treatment* of optic tumors, it is probably wise to use antisyphilitic remedies long enough to exclude lues; after which extirpation of the growth. Surgical interference may, in favorable cases (see **Krönlein operation**) be confined (a) to the removal of the tumor with preservation of the globe; (b) or the eyeball and tumor may be enucleated; (c) or complete exenteration of the orbit may be necessary.

Knapp (*Archiv. of Oph. and Otol.*, Vol. V, p. 132) long ago advised removal of the tumor through a conjunctival opening or through an incision in the lid, when either of these procedures is possible. By means of the fingers and scissors a blunt dissection of the parts is carried out, until the tumor is reached, isolated, pulled forward by forceps and cut off. The eyeball may be forcibly pushed to one side without serious damage. Many successful operations have been reported by this simple means.

Of twenty-five cases of extirpation of optic tumors reported by Finlay there was no recurrence in ten; in eight cases the disease returned either in the orbit or elsewhere. In seven instances death followed—probably from sepsis—shortly after operation.

Optic neuritis. NEURITIS OPTICA. CHOKED DISC. PAPILLEDEMA. PAPILLITIS. The most serious aspects and the most pronounced forms of this condition, their causes, and treatment have already been con-

sidered on p. 2074, Vol. III; as well as under various subsections of **Neurology of the eye,** on p. 8332, Vol. XI of this *Encyclopedia.* See, also, **Albuminuria,** p. 208, Vol I; **Bright's disease,** p. 1296, II, and under affections in which papilledema occurs as a symptom.

To the material found under the foregoing captions may properly be added the following opinions and reports:

One of the best early papers on the whole subject is by Mamourian and C. J. Smith (*British Med. Jour.*, Apr. 8, 1911) who conclude that papilledema results from the lessened or arrested absorption of fluid from the subarachnoid space, in consequence of: 1. Obliteration of the patency of the superior cerebral veins. 2. Disorganization of the perivascular lymphatic sheaths. 3. Occlusion of one or more of the venous sinuses. Optic neuritis is found in association with (a) vascular, (b) organismal, and (c) neoplasmic lesions.

The explanations of the papilledema from thrombosis of the superior longitudinal sinus, as in chlorosis, typhoid, marasmus, pneumonia, etc., is self-evident, being due to the fact that the main channel for the discharge of surplus cerebrospinal fluid is occluded. The observation that the subsidence of the neuritis in chlorosis is due to canalization of the clot lends strong support to this theory. Blockage of the venous stream at any point, more so on the right side, may reduce the same results, and the papilledema of otitic origin is due to lateral sinus thrombosis, especially if the clot extends into the superior longitudinal sinus.

Regarding the association in organismal lesions, the writers consider *syphilis* and *meningitis*. Concerning syphilis, they state that the histology of cerebral syphilis constitutes one of the most important links in the chain of their arguments. The lymphatic sheaths have mainly been studied in this disease as they become thickened and conspicuous. This endolymphangitis is doubtless responsible for the impairment of the absorptive function of the superior cerebral veins. Referring to meningitis they say: "We have already stated that in some cases of extensive basic meningitis there is no optic neuritis. In all probability in these cases the lymphatic sheaths are not involved. Papilledema, however, is bound to result whenever the inflammatory process seals the openings of these intracerebral prolongations of the subarachnoid space."

Considering next the association with neoplasmic lesions, they assert that tumors in the cortex or substance of the cerebrum act by compressing the brain tissue adjacent to them, and ultimately the veins. Obviously, a tumor of the cerebrum must attain a considerable size before it can press upon the veins. A point of some importance is the

well-known fact that optic neuritis is not so common a sequel of abscess in the temporo-sphenoidal lobe as it is of abscess in the cerebellar region, for the simple reason that a much larger accumulation of pus or more extensive accompanying meningitis is needed for its production in the cerebral than in the cerebellar area. On the toxic or inflammatory theory, however, optic neuritis should be equally common in both varieties.

Taking up the question of *tumors of the cerebellum and corpora quadrigemina*, these writers direct attention to the following facts: 1. Optic neuritis is present in 100 per cent. of quadrigeminal, and 89 per cent. of cerebellar, tumors. 2. The neuritis is generally equal and bilateral. (Sir Victor Horsley holds that in its early stages the neuritis is always more pronounced on the side of the lesion.) 3. Subtentorial abscesses are more frequently accompanied by optic neuritis than abscesses in the cerebrum. 4. A condition of internal hydrocephalus is present in connection with cerebellar and quadrigeminal tumors with optic neuritis. Growths or abscesses in the cerebellum or tumors of the corpora quadrigemina bring about compressional closure of the iter, which may also be closed by intraventricular tumors. The foramina of Magendie and Luschka may become occluded by lymph or scar stenosis (meningitis). The secretion of cerebrospinal fluid being uninterrupted, the shutting off of its natural outlet results in the production of internal hydrocephalus. The dilatation of the ventricles under considerable internal hydraulic pressure cannot but produce collapse of the delicate veins in the brain substance, and therefore cessation of cerebrospinal fluid absorption. It may be argued that, there being no increase of fluid in the subarachnoid space owing to the non-patency of the iter or the foramen of Magendie, there should be no rise of pressure in the subarachnoid space, and therefore no neuritis. It must be borne in mind, however, that by the dilatation of the ventricles the size of the brain generally undergoes increase, and the cerebro-cranial space becoming diminished, the intervening fluid, however small in quantity, is bound to be subjected to pressure, and driven into the sheath of the optic nerve, and at the same time plays the rôle of an additional force in compressing the veins.

Henderson (*Ophthalmic Year-Book*, p. 266, 1912), as a result of experimentation and general consideration of the subject of the pathogenesis of papilledema, concludes: 1. The intraocular and intracranial pressure are under physiological conditions similar in nature as in level, and choked disc is a manifestation of a disturbed equilibrium between these two pressures. 2. When the intracranial pressure

is raised, the cerebral venous pressure mounts to the same level and therefore the pressure in the neural portion of the retinal veins likewise rises. Hence to complete the retinal circulation, the pressure in the intraocular portion must rise pari passu, thereby producing the venous retinal engorgement. 3. As fluids tend to lie at the lowest hydrostatic level, and as the hydrostatic pressure behind the lamina cribrosa is greater than in front, fluids pass forward into the now lower hydrostatic level of the eye, and so cause swelling of the disc. 4. The arching forward of the lamina cribrosa and the so-called hydrops vaginæ represents a yielding of these structures to the increased hydrostatic pressure they are called upon to support. 5. The brain acts as a viscous and not a fluid mass; and further, as the rigidity of the falx and the tentorium tends to hinder general diffusion of hydrostatic pressure, in one cerebral hemisphere and corresponding optic nerve it may arise above that in the other, thereby accounting for the ipsolateral feature of choked disc.

According to Behr papilledema is only a clinical manifestation of edema of the optic nerve trunk. In intracranial processes the compression of the circulation is at the cerebral opening of the bony canal. Whether this be due to swelling of the brain substance or to hydrocephalus internus, there must be a complete closure of the intervaginal space. This is manifested in a typical concentric contraction of the field, and a relative sparing of the papillomacular bundle. Should the compression lead to a serious injury to the entire nerve fibre stem amaurosis with increasing degeneration of the nerve fibres occurs. Together with this there is a decrease in metabolism. Extracranial situations of compression are the optic canal and orbit, carotid aneurism, tumor, hemorrhage and hematoma of the sheath. In papilledema of anemia and polycythemia the cause is an overwhelming production of free tissue fluids resulting from an altered condition of the vessel walls. In papilledema there are found saucer-like formations on the surface of the optic nerve in its intracranial portion at its exit from the bony canal; degeneration of the nerve fibre bundles beneath the pial sheath; extension of the edema which is present only in the intra-orbital and intracranial portions of the optic nerve, extending always just to the point where the nerve reaches the base of the brain; noninflammatory growth of the endothelium and marked increase in the corpora amylacea in the intervaginal space, which is explainable on the basis of a chronic lymph stasis and is characteristic of papilledema.

Schieck's contribution to this study is in three heads: 1. Clinical observations. In six cases he was able to study the fundus changes in

their incipiency. The first sign consisted in a concealment of the papilla where the large vessels escape from the porus opticus. There are two reflexes on the vessel walls. Soon an actual exudate throws a light cloud into the vitreous. Next there appears on the contour of the vessels a peculiar bright streak of varying breadth, evidence of distention of the perivascular lymphatics. There is also a fine streaky haziness of the disc and the adjacent retina with a slight but increasing haziness of the edges of the disc in the region where the vessels pass over it. As the process extends it involves the disc above and below, the horizontal meridian remaining clear the longest. He regards the degree of venous congestion and arterial constriction as accidental symptoms. Venous congestion and retinal hemorrhages play so important a part in optic neuritis that they are of no diagnostic value for choked disc. Spots of fatty degeneration belong to the later stage, as it requires time for the edema to enter the nerve fibres. After a time the papilledema subsides, or anatomically speaking, the flow of fluids into the perivascular spaces ceases and the subsidence of the phenomenon is the reverse of its occurrence.

2. Microscopic examination was made of eight eyes, three cases of recent papillitis and one in the atrophic stage. There was no sign of inflammation but only invasion of fluid. The perivascular lymph spaces in the central bundle at the entrance of the central vessels was not closed, but in open communication with the intervaginal space. In the beginning the lymph space is constantly found distended, but the papilla is involved later. Here there is very marked distention of the perivascular spaces around the branches of the central vessels, which is quite characteristic. He believes the evidence sufficient to prove that the filling of the space is not related to a distention of the central vessels, but that there is a flux of fluid into the lymph spaces in a peripheral direction. This distention of the spaces is seen whenever there is obstruction. It occurs at the lamina cribrosa; and, owing to the counter pressure of the vitreous, the fluid fills the perivascular spaces of the retinal vessels, and so appears as an edema of the tissues of the papilla. The case with definite atrophic changes showed evidences also of severe inflammation.

3. Investigation of postmortem eyes. The intervaginal space was injected with yellow fluid gelatin. It was injected so as to produce a well marked ampulla at the blind end of the vaginal space. Microscopically, it was found that the fluid escaped into the tissues around the central vessels, giving rise to an edema of the central bundle. The perivascular spaces become distended and this may give rise to a compression of the lumen of the vein.

4. Animal experimentation. The animals selected were monkeys and two methods of increasing the intracranial pressure were used, by introducing sponge through a trephine opening and by injecting fluid. When the piece of sponge was introduced intracranially the results were not altogether satisfactory but changes took place in the papilla which he thought indicated beginning papilledema. When introduced extradurally papilledema was definitely produced. After a time the fluid escaped from the trephine opening and collected under the skin resulting in a subsidence of the papilledema. If the fluid was evacuated and a firm bandage applied the papilledema returned. Another question studied was whether encroachment upon the intracranial space could cause papilledema, or whether an increase of the intracranial fluid was a necessary preliminary. The latter was found to be the answer. He concludes that increase in pressure alone within the skull is not sufficient to produce papilledema; but that increase of the intracranial fluid on the same side is a second and indispensable factor. He does not believe that the fluid is of inflammatory origin and holds that the papilledema is due to the quantity and pressure and not to the quality. Papilledema is the ophthalmoscopic, visible expression of the increased cerebrospinal fluid, which reaches the intervaginal space and finds an outlet in the pre-existing lymph sheath of the axial bundle along the central vessels and flows into the papilla from behind. Experimental work supports ipsolaterality, and he thinks that the papilledema sets in on the side on which there is a greater amount of fluid present. In a series of cases this will be the side on which the tumor is, as Horsley maintains. The relationship of tumor to increased production of fluid is not understood.

A series of clinical observations which tends to show that *optic neuritis* is not as rare as ophthalmologic literature would lead us to believe is reported by Hubbell (*Jour. Amer. Med. Assoc.*, July 7, 1906). A summary of the cases shows that the optic nerve was affected in four of them, intraocularly in three, retroocularly in one. Three were females and one male, with ages varying from 16 to 43, and all apparently in good health. All four cases recovered with almost normal fundus and vision. In four cases the inflammation involved both nerve and retina. Two were males and two females, one of 24, all the others being over 61. One patient had calculi and inflammation of the right kidney, one had questionable general arteriosclerosis with chronic albuminuria. In three cases the vision was practically lost by atrophy. In one it was regained and became nearly normal. In ten cases the inflammation was apparently limited to the retina and varied greatly in intensity. Three cases recovered, one was lost, and

in six the result is unknown or still undecided. General condition was good in six cases. In three cases there was arteriosclerosis. Hubbell has never seen a case of optic neuritis that was not uniocular, except when there was syphilis or brain tumor, nor a case of neuroretinitis or of retinitis that was not uniocular, except when there was double orbital cellulitis, Bright's disease, diabetes or syphilis, and then it was typical of these diseases. Treatment has invariably been the administration of the iodids.

Optic neuritis of nasal origin has already been to some extent discussed under **Cavernous sinus** as well as under **Cavities, Neighboring,** in Vol. III of this *Encyclopedia.* The paper of Paunz deals further with the subject. He (*Pr. Med. Series*, p. 107, 1911) believes that acute or chronic neuritis of the optic nerve can be brought about by an inflammation of the posterior accessory sinuses of the nose, even when no orbital phlegmon exists. Both optic nerves may become affected although the infection in the nose be only unilateral. The power of vision diminishes in very acute cases very rapidly, and this is followed by total blindness in a few days. In all cases there was color scotoma.

Ophthalmoscopically, one finds papillitis, venous hyperemia, temporal paleness; and sometimes no visible change could be observed. The more acute the case, the more gratifying will be the result of operative interference in the nose.

Francis and Gibson, from their investigation of the protection of the chiasm and optic nerve from the *sphenoidal sinus*, the study of diverticula extending from this sinus towards the orbit, and observations covering the blood supply of the parts, upon 60 cases, reach the following conclusions: One-third of optic nerves and commissures are shielded from the sphenoidal sinus by a bony wall measuring one-fourth of a millimeter or less in thickness; and in another third the wall measures one-half of a millimeter or less. Of their specimens 17 per cent. presented diverticula approaching or invading the orbital wall. They believe that the sinus depends, in part at least, upon the arterial supply of the periosteum of its walls and the adjacent cavities. Onodi has continued his anatomical studies of the relations of the ethmoidal and sphenoidal sinuses to the optic nerve, and has demonstrated four preparations in which free communication existed between the sinus and the optic canal. He points out how extremely easy it would be in such a case for the sensitve papillo-macular fibres to become affected by sinusitis.

Knapp reports a case in which, with nausea and frontal headache, vision had been reduced to 20/70, with a central relative scotoma. After resection of the middle turbinal there was free escape of pus.

Vision had improved next day and in 7 weeks had become normal. In this case there was pronounced neuro-retinitis with a radiating figure at the macula. The ophthalmoscopic appearances also became normal. In another communication Knapp records a still more remarkable case, of bilateral optic neuritis with ethmoiditis. In the left eye light perception was lost, and the pupil was irresponsive. The swelling of the disc was $2\frac{1}{2}$ D. Vision began to return the day of operation on the middle turbinal. Later the left eye became affected; vision 20/100, the nerve hazy, with central scotoma. Under treatment vision became normal in both eyes. In each case there was a scotoma which gradually became smaller and disappeared. A case of retrobulbar neuritis following ethmoidal disease, and showing almost immediate improvement when the ethmoid was evacuated, is reported by Rethi. Under diaphoretics, one eye recovered almost completely, and the other from almost total blindness was greatly improved.

Syphilitic optic neuritis is extensively discussed by de Lapersonne (*Arch. d'Ophtal.*, Vol. 33, Aug., 1913) an admirable review of which by R. R. James will be found in the *Oph. Review* for Nov., 1913.

The writer mentions the work of Uhthoff (1900), and Dufour and Gonin, the former in 253 cases of neuritis of infectious origin proved 51 due to acquired and 10 due to hereditary lues; the latter divided cases into early and late.

Early optic neuritis appears quickly after the primary lesion, six weeks (Groenouw), five months (Soemiskiewicksch), three to seven months (Lapersonne) after the healing of the primary sore. Frequently it is unilateral, and accompanies the cutaneous or mucous manifestations of the secondary period, the clinical aspect has nothing characteristic about it, and its origin in syphilis cannot be proved by ophthalmoscopic examination.

In 30 cases of optic neuritis in which syphilis was found, Smith observed 14 papillitis, 17 neuro-retinitis, and 3 retrobulbar neuritis.

Such a neuritis may terminate in complete cure, without leaving any ophthalmoscopic traces of its past presence, but some degree of post-neuritic atrophy is more usual, and it is often difficult to harmonize the functional symptoms with the lesions found in the fundus.

To explain the precocity of the lesions, the different clinical aspects, and the variable prognosis it is quite certain that the idea of an interstitial or parenchymatous neuritis is not satisfactory, and de Lapersonne falls back on the theory of a meningitis of the optic nerve; the sheaths of the nerve, more particularly the arachnoid and pia, are primarily involved, the infiltration penetrating into the interfascicular spaces of the nerve and affecting the neurons secondarily.

If we admit the possibility of an infiltration of the sheaths anywhere between the globe and the optic canal, the varying clinical pictures of papillitis, edema of the nerve and retina and descending neuritis are easily explained.

Having proved the syphilitic origin by means of the Wassermann reaction, performed both on the blood and on the cerebrospinal fluid, de Lapersonne begins energetic treatment.

As a general rule his treatment is divided into two kinds, one for the late cases and the other for the early. In the subsidiary lesions, such as the atrophies, intra-muscular injections of an emulsion of sublimate are employed, the injections being made every second day for about a month; if injections are not well borne, he has recourse to inunctions, and gives iodide by the mouth. He has entirely given up the use of mercury in pills or potions.

The more energetic treatment for early cases consists of a series of intravenous injections of cyanide of mercury, about a dozen given every other day, followed by injections of salvarsan or neo-salvarsan, three or four doses of salvarsan being given, with intervals of eight days between, and the last dose of salvarsan is again followed by another series of a dozen cyanide injections.

Wilder (*Year-Book*, p. 242, 1916) reports two cases of optic neuritis from syphilitic leptomeningitis, which exhibit the characteristic symptoms of this condition, and illustrate the insidious nature of the disease, the suddenness of development of the eye symptoms, and the prompt response to treatment that may sometimes follow. In the first case, that of a young woman of 20, the diagnosis was made after the most thorough examination. Her vision when first seen was zero in each eye. Both optic discs were blurred and swollen to about 1 D., and the physiologic depression was obliterated. She was treated by mercurial inunctions, increasing doses of potassium iodid, and received several intravenous injections of neo-salvarsan. Within a week after treatment was instituted she began to perceive light with the right eye, and in about five months she could even read letters about 2 centimeters high several feet from the eye. There was no improvement of vision in the left eye.

In the second case, that of a woman 40 years of age, a similar diagnosis was made from the clinical examination and the laboratory findings. Sudden blindness came on in one eye. There was not the faintest perception of the strongest light, nor the slightest direct response of that pupil to such light, although its consensual reaction was prompt and almost normal. Ophthalmoscopic examination revealed no change in the optic disk nor in the fundus. She was imme-

diately given hypodermically 0.3 c.c. of 45 per cent. emulsion of mercury. In four days after beginning the treatment she could distinguish hand movements close to her eye, and there was a slight reaction of the pupil to light. The condition improved rapidly under treatment, and in about two weeks reached 20/30, where it remained. The absence of ophthalmoscopic signs was a noticeable feature in this case, but it may be that evidence of optic atrophy may appear later.

Knapp reports a case of bilateral optic neuritis after influenza caused, he believes, by a hematogenous infection which at the same time produced a slight toxic reaction on the part of the cerebrospinal fluid. There was associated with the neuritis a star-shaped figure around the macula, resembling that found in albuminuric retinitis. The field defect was a central color scotoma. The optic neuritis ran the usual course, uninfluenced by treatment. After three weeks the ophthalmoscopic changes disappeared, the star figure in the macula going last. The vision which was about 20/200 at first improved to 20/30.

The important question of the *operative treatment of papilledema* is discussed by Kaelin-Benziger (*Zeitschr. f. Augenheilk.*, Jan., 1913) in the light of 35 cases of choked disc, mostly bilateral, observed by him within 17 years.

The author reached the following conclusions: 1. The certain diagnosis of bilateral choked disc is an unconditional indication for decompression of the brain by operation, even if the visual function of one or both eyes is still normal. Thus, the dangers are less and the results best. 2. The greater the damage to the optic nerve from pressure, the poorer are the operative prospects for preservation or improvement of function. There is no likelihood of a spontaneous cure of choked disc, therefore it must not be counted on. 3. Since in most cases of brain tumors the causes of choked disc can not be removed and the augmentation of the physiological outlets of cerebrospinal fluid is impossible from the start, the only therapeutic measure to be considered is a new permanent outflow or a permanent enlargement of space for expansion of the brain. 4. As experience shows that a solid tumor is often complicated by hydrops of a ventricle, the opening must be combined with temporary extracranial and permanent intracranial drainage. Therefore simple trephining can suffice only in very rare cases. 5. If localization is impossible, the parietal region is preferable. 6. The writer has no experience as to lumbar puncture or puncture of the corpus callosum. 7. In his cases the cerebral symptoms and the choked disc disappeared in from 24 hours to two weeks after the operation. None of the patients died in consequence of the opera-

tion. 8. In every case the therapeutic plan must be determined by the ophthalmoscopic state of the choked disc.

Bourguet and Ronnaux report a case of double optic neuritis cured by puncture of the corpus callosum. The patient was a war prisoner, 24 years of age. A month previously he had an attack of la grippe, and shortly after this noticed that his vision was markedly failing. The operation was performed under local anesthesia. At the time of operation vision in the left eye was 3/50. In the right eye there was the appearance of beginning optic atrophy. All his symptoms were relieved immediately after the operation, and in a few weeks vision was normal in both eyes.

Optic neuritis, Orbital. RETROBULBAR NEURITIS. See **Amblyopia, Toxic**; also the major heading, **Retrobulbar neuritis.**

As this condition, in common with many other diseases of the optic nerve, is set up by rheumatism, possibly syphilis, typhoid fever, and other infectious and systemic diseases, the treatment of the underlying factor is most important. On the whole large doses of salicylate of sodium, (q. v.) give good results in both the rheumatic and other types. The next best plan is that of full doses of the iodides, with pilocarpin sweat baths. If the disease tends to become chronic and the ophthalmoscope shows the subsidence of inflammatory signs, quinine, strychnia, and other tonics should be substituted for the salicylates and iodides. The hygienic treatment of all stages of this disease is very important.

Fleischer, in ophthalmoscopically marked optic neuritis, found, in 5 out of 12 cases, multiple sclerosis. He believes that acute retrobulbar neuritis is frequently a symptom of multiple sclerosis. Therefore in acute retrobulbar neuritis the diagnosis of incipient multiple sclerosis may be made with the greatest probability, if no other cause, such as propagated inflammations or intoxications, can be discovered.

A chronic retrobulbar neuritis is often the lesion in toxic amblyopia (q. v.), and when the diagnosis is established it should be treated accordingly.

Optico-choroidal vessels. One of the few reported cases is by W. T. Shoemaker, who has met with a case of optico-ciliary vein. In this instance optico-choroidal is suggested as better describing the vessel which he took to be a choroidal vein running into the central retinal vein, instead of passing to the veins of the nerve sheath.

Opticociliary. Pertaining to both ciliary and optic nerves.

Opticociliary neurectomy. See p. 4456, Vol. VI of this *Encyclopedia;* also **Neurectomy, Opticociliary,** on page 8324, Vol. XI.

Optico-ciliary vessel. This exceedingly rare condition, normal in some lower mammals and other animals (see **Comparative ophthal-**

mology), is shown in van der Hoeve's (*Oph. Year-Book*, p. 200, 1916) case of exudative retinitis. Just after leaving the disc the superior temporal artery gave off a branch which curved towards the papilla and, after giving off a very thin branch in the retina, disappeared at the disc margin. Only one other case, the one of Oeller, is known, according to Leber.

Opticocinerea. (L.) The gray matter of the optic tract.

Opticol. A name given to a series of American proprietary remedies said to be useful in diseases of the eye.

Opticonasion. The distance from the posterior edge of the optic foramen to the nasion.

Opticopupillary. Pertaining to the optic nerve and the pupil.

Optic papilla. Optic disc. See p. 4031, Vol. VI of this *Encyclopedia*.

Optico-trochléi-scléroticien. (F.) The superior oblique.

Optics. That branch of physical science which treats of the nature and properties of light, of the theory of colors (chromatics), of the change which light suffers either in its qualities or in its course when refracted or transmitted through bodies (dioptrics), when reflected from their surfaces or when passing near them (catoptrics), of the structure of the eye and the laws of vision, and the construction of instruments of introspection, as telescopes, microscopes, etc. *Geometrical optics*, the theory of the foci of lenses and mirrors, with other purely geometrical theories connected with light. *Physical optics*, that branch of optics which includes the phenomena of diffraction, interference, double refraction, and in general that division of the subject which is explained by reference to the undulating theory and the behavior of light-waves under various conditions. *Physiological optics*, that branch of physiology which treats of the refraction of the eye and the sight function.—(C. F. P.)

Optics, Physiological. See **Physiological optics.**

Optic tracts. See **Intracranial organs of vision.**

Opticus. (L.) The optic nerve.

Opticuscentrum, Infracortical. A term used by Monakow for the corpora quadrigemina, as distinguished from the visual centres in the occipital cortex.

Opticusschwund. (G.) Phthisis bulbi.

Optigraph. A form of telescope constructed for the purpose of copying landscapes, etc. It is suspended vertically in gimbals by the object-end, beneath a fixed diagonal plane mirror, which reflects the rays from the objects to be drawn through the object-glass of the instrument to a speculum, and thence through the eye-glass to the eye. Between the eye and the speculum is a piece of parallel-faced glass with a small

dot on its center, exactly in the focus of the eye-glass. This dot is made to pass over the outline of an object, and a pencil fixed at the eye-end traces the delineation on paper.

Optimeter. Same as optometer.

Optischer Brennpunkt. (G.) Visual focus.

Optische Täuschungen. (G.) Optical illusions.

Optisches Auge. (G.) Optical model of the eye.

Optist. A person skilled in optometry.

Optochin. ETHYL-HYDROCUPREINE. See p. 3459, Vol. V of this *Encyclopedia.* The most recent and most reliable account of the chemical composition and clinical status of this agent is given under New and Nonofficial Remedies in the *Journ. Am. Med. Assocn.*, p. 713, March 3, 1917. The report gives optochin as a synthetic derivative of cupreine, $C_{19}H_{22}O_2N_2$, an alkaloid occurring together with quinine in the bark of *Remijia pedunculata.* Ethyl-hydrocupreine is closely related to quinine, differing from the latter in containing two more hydrogen atoms and an ethoxy in place of a methoxy group. The drug has the antimalarial and anesthetic action of quinine. Toxic symptoms, however, such as tympanitis, deafness, amblyopia or amaurosis (retinitis) are more liable to occur than with quinine; while these are generally transient, retinitis may result in permanent impairment of vision (in one case amaurosis resulted from the administration of two 0.25 gm. doses). This demands caution in the use of the drug. Ethyl-hydrocupreine has a specific bactericidal effect on the pneumococcus in vitro, and it exerts a protective and curative action in animals experimentally infected with virulent strains of pneumococci. Clinical investigation indicates that the drug may be of value in the treatment of lobar pneumonia when the proper dosage is determined. Owing to the toxicity of the drug, it seems that the amount which can safely be administered to man is limited. For adult males, 1.5 gm. by mouth in twenty-four hours, divided into at least three doses, may be considered safe, but even in this dosage slight toxic effects have been seen. The drug may be given intramuscularly, but it is liable to be irritant. Intravenous administration seems contraindicated.

While the internal use of ethyl-hydrocupreine is in the experimental stage and the danger of visual disturbance (amaurosis) makes caution in its use important, reports indicate that the drug is of decided value in the treatment of pneumococcic infection of the eye (ulcus corneæ serpens). It is too soon to give a definite opinion as to the actual value of the drug in curing pneumonia.

For ophthalmic use a freshly prepared 1 to 2 per cent. ointment or solution in a bland fatty oil.

Optochin is a white or fainty yellowish, amorphous, odorless powder having a bitter taste. It is nearly insoluble in water; easily soluble in alcohol, ether and chloroform; easily soluble in dilute acids; very slightly soluble in petroleum ether.

If about 0.1 gm. of optochin be dissolved in 20 cc. of water by the aid of a few drops of diluted sulphuric acid, 1 cc. of bromine water added and the solution made alkaline with ammonia water, a green color should be produced.

If about 0.5 gm. of optochin be dissolved in 10 cc. of water by means of a few drops of diluted sulphuric acid, the solution made alkaline with sodium hydroxide solution and the mixture boiled, no odor of ammonia should be produced.

If 0.1 gm. of optochin be dissolved in 20 cc. of water by the aid of a few drops of diluted sulphuric acid, a blue, fluorescent solution should be produced; if 0.3 cc. of tenth-normal potassium permanganate be added to this solution the violet color should persist for at least one minute (quinine and some other impurities).

If 0.01 gm. of optochin be dissolved in 0.2 cc. of strong sulphuric acid, not more than a slightly greenish-yellow color should be produced (readily carbonizable organic impurities).

If from 0.5 to 0.8 gm. of optochin be weighed and incinerated, not more than 0.1 per cent. of residue should remain.

The hydrochloride of ethyl-hydrocupreine, has the same actions, uses and dosage as optochin.

The usefulness of this agent in spreading—generally pneumococcic—ulcer of the cornea is undoubted. H. Lystad says that it has a specific or directly toxic action on pneumococci of the most varied strains, although scarcely or not at all upon a number of other bacteria with which experiments have been made. It is commonly used in one or at most 2 per cent. watery solution of the hydrochloride, being instilled freely every one or two hours. The solution must be fresh (not older than three weeks), and must be kept in a brown glass container. The first instillation hurts slightly, the later ones usually not at all, since optochin produces a prolonged anesthesia or hypesthesia of inconstant character. Two per cent. optochin oil seems to be inactive, but the 1 to 2 per cent. salve of the basic drug is perhaps as efficient as the watery solution.

In most cases of ulcus serpens corneæ the use of optochin causes a prompt arrest of the advance of the disease, and exceptionally rapid cleaning of the ulcer as well as a less dense opacity than usual. In dacryocystitis it is not possible to get rid entirely of the pneumococcus, but the use of the new drug seems to produce a marked diminution

in virulence, resulting in a marked lessening of the suppurative element in the discharge. In pneumococcus bearers, who carry the pneumococcus in a normal or chronically slightly inflamed conjunctiva, the pneumococci can be disposed of in twelve to twenty-four hours with a 1 per cent, solution used every two hours—a fact which is likely to prove important in preparing for eye operations, or in the presence of erosions and foreign bodies.

Elena Puscarin (*Klin. Monatsbl. f. Augenheilk.*, 53, p. 342, 1915) reports eight cases of gonorrheic blennorrhea, treated with instillations of hydrochlorate of optochin (ethyl-hydrocuprëin), 1 per cent. every hour and 2 per cent. every two hours, after previous removal of all discharge with lotions of boric acid. In recent cases and in the later period of the disease the gonococci disappeared after a few days; at the most, treatment lasted two weeks. Optochin employed thus was found by this writer to be superior to nitrate of silver.

On the other hand the fact that in a number of cases optochin has produced a *toxic amblyopia* must not be lost sight of. One of these instances is reported by W. Feilchenfeld (*Deut. med. Woch.*, March 16, 1916). Five grams of optochin were given to a twenty-year-old pneumonia patient, in hourly doses of 0.2 grams each. Within two days poor hearing developed, and on the next day there was a decrease in vision. Complete blindness set in on the subsequent day. The pupils were found to be dilated ad maximum. The fundi were normal except for a narrowing of the vessels on the disc. Sodium iodid was given in large doses, as well as tincture of strophanthus. Under this treatment there was a gradual recovery, first of the hearing, and eventually of the sight. Two months later the corrected vision was 6/6, although there was a concentric contraction of the visual fields and large paracentral scotomata. Hemeralopia and "*flimmer*" scotoma gave the patient a great deal of subjective annoyance. The ophthalmoscope showed a bilateral optic atrophy.

Optocine. An organic extract from the retinæ of freshly killed animals so prepared that one fluid ounce contains the remedial activities of four retinæ. Introduced by R. W. Doyne and advised by him for the treatment of retinitis pigmentosa, tobacco amblyopia, myopic choroiditis and other fundal lesions. It has not attracted much attention.

Optogram. A faint image, at one time thought to be occasionally visible on the retina for a short time after death, of the last object perceived by the eye of a person just before death. See, middle third of the section **Legal relations of ophthalmology,** in this *Encyclopedia.*

Optograph. A photograph of an optogram.

Optologist. A term, now fallen into disuse, intended to denote an optician who devotes himself solely to vending spectacles and eyeglasses and to the diagnosis and correction of errors of refraction.

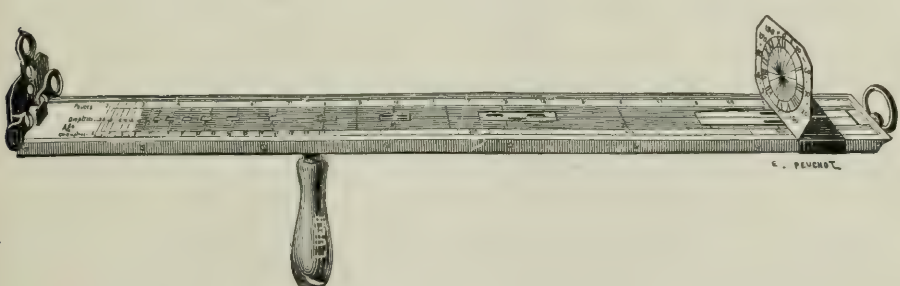
Optomeninx. An ancient name for the retina.

Optometer. An instrument for measuring the refractive and accommodative powers of the eye. It is generally a hand or stationary device and mostly employed by opticians without the aid of a cycloplegic. The best known examples are described or depicted in alphabetical order of the inventor, as follows:

See, first, **Accommodometer**, p. 55, Vol. I of this *Encyclopedia.*

Optometer of Badal. This simple instrument is described by Tscherning (*Optics,* p. 160).

Optometer of George Bull. This instrument for rapid optometry was described by the inventor in Vol. 5, 1887, p. 5 of the *Bull. et Mem. de la Soc. Frs. d'ophtal.* As shown in the figure it is intended to measure refraction at the near point and to measure the amplitude of accommodation. The device is furnished with three movable eye pieces (lenses), test figures, astigmatic chart, etc.



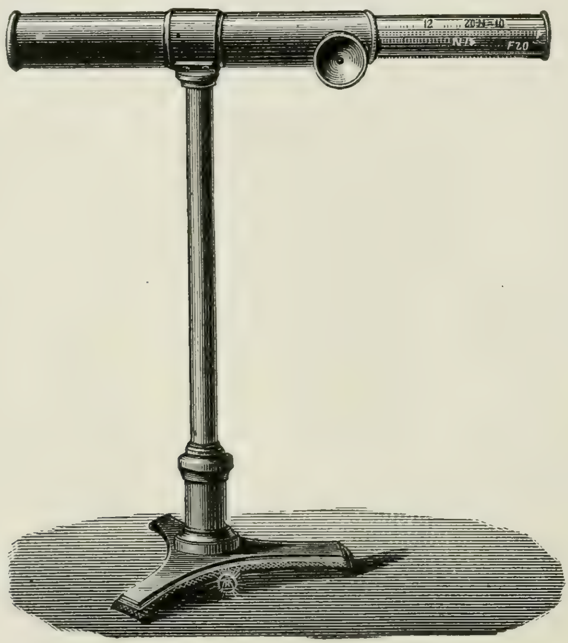
Bull's Optometer.

Burow's optometer. This instrument consists of a tube which can be elongated, in the ocular end of which is a lens of 4-in. focus, while in the other end is a ground-glass plate with test types photographed on it.

Culbertson's prismoptometer. This device, depending for its action on the well-known experiment of Scheiner (See **Physiological optics**), is described under **Prismoptometer.**

Donders' and Hasner's optometer. An optometer consisting of a horizontal rectangular board, 5 feet long and 9 in. wide, which stands on a pedestal. Three grooves run its entire length, into which, by suitable manipulation, a bar with a perpendicular wire-optometer or a

screen with fine openings may be shoved. The distance between the two outside grooves measures $20\frac{1}{2}$ lines, and nearly corresponds to that between parallel visual lines. If the object is moved in the middle groove, both eyes strongly converge. At one end of the board is a gap for the nose of the patient, and in front of his eyes are two semicircles for holding the correcting-glasses. Two vertical rods maintain the head in place by pressure on the malar prominences. (Dorland).



Burow's Optometer.

Holden's optometer. An instrument consisting of a disc with two perforations in it, 1 mm. in diameter and 4 mm. apart, through which the patient looks at a flame. Before one of the apertures a vertical prism tinted red is placed. Two images of the flame are then seen, which, if the patient is emmetropic, are one over the other, but which, if he is ametropic, are oblique. In the latter case the prism is rotated until the images stand in the same vertical line, when the degree of rotation indicates the amount of ametropia.

Hoppe optometer. This instrument, as shown in the accompanying figure, is a complicated apparatus provided with mirrors for both natural and artificial illumination of the test charts. It is fully de-

scribed in the *Bericht der Oph. Gesellschaft*, 1908, to which the reader is referred.

Hoppe's Mirror Optometer.

Hair optometer. See **Hair optometer,** p. 5676, Vol. VIII of this *Encyclopedia.*

Javal's optometer. An optometer for the rapid determination and correction of astigmatism. It is in the form of a stereoscope, mounted on a stand, and supplied with convex spherical lenses of about 5 in. focus. Two circles are drawn side by side on cardboard, as in a stereoscope plate, the distance between their centres corresponding to that between the eyes. In one figure are drawn a series of radiating lines, and at their extremities are placed the figures I to XII. If the visual lines are parallel, the two circles are fused into one image, in the centre of which lie the radiating stripes and at the circumference the figures. By means of a screw the circles are removed farther and farther from the eyes, until all the radiating lines except one become indistinct. The direction of this one corresponds to the diameter of the highest refraction. Behind the ocular lens of the one eye a series of concave cylindrical lenses are so arranged on a pivot that they can be rapidly

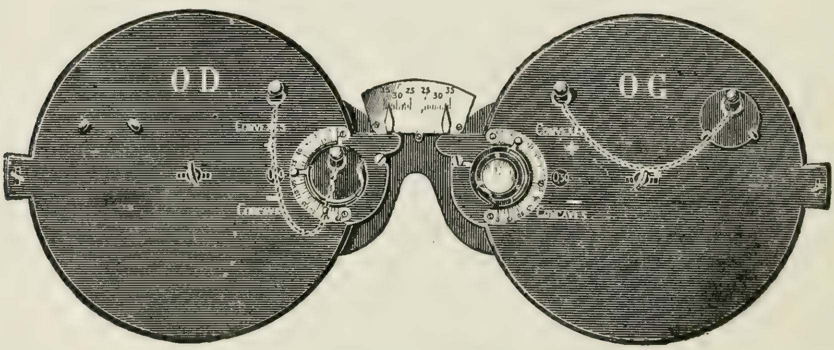
rotated in front of the eye until the lens is found which corrects the astigmatism and indicates its degree. (Dorland.)

Landolt's ophthalmodynamometer. See p. 473, Vol. I of this *Encyclopedia.*

Laurence's optometer. An optometer consisting of a shoemaker's rule which bears on one of the slides a page with printed letters.

Lehôt's optometer. This form of the instrument consists of a three-foot rule covered with black velvet. Along its entire length runs a white thread. If one end of the optometer is pressed against the lower eyelid in a horizontal direction, the thread at the distance of distinct vision appears single, but on both sides of this double.

Le Mehauté's optometer. In this device an attempt is made to displace the usual trial frame and test case by a portable apparatus;



Le Mehauté's Optometer.

otherwise there is nothing new about it. A small (portable) box contains very small lenses, adjustable to the nose frame openings. See the figure.

Optometer of Mile. For a description of this apparatus see Tscherning's *Optics,* p 75.

Optometer of Scheiner. Several optometers, notably Culbertson's (q. v.), have, in addition to this one described by Tscherning (*Physiological Optics,* p. 75), been devised based on the well-known experiment of Scheiner.

Smee's optometer. This device is in the form of a graduated scale, along which may be moved a board with test types on it. At the ocular end are four convex glasses: 1/20, 1/10, 1/5, 1/2½. Through one of these glasses the test object is observed.

Stampfer's optometer. An instrument depending on the same principle as Young's optometer. It consists of a tube which may be elon-

gated, at the ocular end of which are a convex lens of 5 in. focus, and a plate with two slits about 1/3 line wide and 1/2 line apart. A slit on the other side of the tube, 1/20 line wide, serves as a fixation object; it runs parallel with the other slits, and is covered with ground glass. The distance at which the slit is seen single is determined by shoving in and out this lattice.

Weiland's optometer. A full description of this optical device is given in Tscherning's *Physiological Optics,* p. 135.

Young's optometer. An optometer consisting of a small ivory plate, 8 in. long and 1 in. wide, with a black stripe along its entire length. At one end there is a vertical metallic plate with parallel vertical slits. While this is held as near as possible to the pupil, the eye fixes the black line. This appears double for all distances outside the point of accommodation. An index, movable on a scale on the optometer, marks the point of single vision.

Optometer, Von Graefe's. Wire optometer. This instrument, for measuring the range of accommodation, consists of a small square steel frame, across which a number of delicate parallel vertical wires are stretched. The frame may be attached to a graduated brass rod, on which it is movable. One end of the rod is placed against the forehead of the patient, and the frame is moved to the nearest point at which the individual wires still look clearly and sharply defined. The distance of this point from the eye is read off from the graduated scale and put down as the near point. The frame is then removed to the greatest distance at which the individual wires still appear sharply defined, and this is noted as the far point. The distance between gives the range of accommodation. (Foster.) See, also, p. 5676, Vol. VIII of this *Encyclopedia.*

Optometrist. One who practises optometry; an optician.

Optometry. 1. The measurement of the range of vision. 2. The measurement of the visual powers in general (including the acuteness of the perception of form, of light, and of colors—eidoptometry, photoptometry, and chromatoptometry, respectively), of the extent of the visual field (perioptometry), of the accommodative and refractive states of the eye (dioptometry), and of the position and movements of the eyeball (ophthalmostatometry and ophthalmotropometry). 3. The measurement of visual acuity and the fitting of glasses to correct visual defects. A term adopted by opticians who prescribe and fit glasses.

It is not proposed in this *Encyclopedia* to discuss the many burning questions that have recently arisen regarding this comparatively new occupation, but this may be said;—In commenting on the paper of Roberts (*Pr. Med. Series,* Eye, p. 26, 1911) the Editor said that

some of the problems involved in eyestrain and its treatment are properly set forth by the writer (*Am. Medicine*, Dec., 1909) who is of the opinion that "present-day measures are not inadequate to this end; and the profession, to increase its power for good, should bury its dissensions, call in all available aid, and co-operatively study the problem in all its aspects. A sufficient number of medical men should qualify themselves and take up the work of bringing the eyes of the race to their highest efficiency." Since then the Editor sees no occasion to alter his opinion expressed as follows at that time:—

There can be no doubt but that if the medical profession as a whole does not in some effective manner provide for the needs (or demands) of that rather large percentage of the laity who continue to frequent the shops of the optician the so-called "optometrist" will, sooner or later, under pressure of public opinion, receive legal recognition, either through legislative action or, as in the case of Columbia University, by the establishment of optical (or optician's) courses. For good or evil, that portion of the public that goes (or is sent by physicians) to the optician believes that much of the oculist's work is as well done by the "optometrist" as by the ophthalmologist. They also learn, or are being taught, that doctors are pursuing a sort of dog-in-the-manger policy in that they are opposed to "simple refracting" by a "qualified" optometrist and still refuse to do such work themselves. Another section of the community declines for various reasons to seek the aid of hospitals and dispensaries, while still another—mostly rural and suburban—are the victims of a totally incompetent and generally charlatanic "traveling" order of opticians. Will the States follow the example of the University of Michigan and the advice of Leartus Connor and train a sufficient number of their students, either before or after graduation, to meet this growing demand for "simple refracting"?—or will the subject of refraction be treated, like dentistry, as a part of medical teaching, be erected into a separate (and separated) branch to be taught in much the same way? Will it, in that case, lead to a special degree, be subject to examinations for a State license (under the control of the usual State machinery) or will "schools of optometry" be permitted? We know that the subject is one involving grave consequences, both lay and professional, but it seems that the time has arrived for action of a sort that will meet the demand for more effective (and cheaper) refractive work than the oculist is now able to furnish the public. We need not add that our own influence is decidedly in favor of keeping what is obviously a part of the practice of medicine, under the care, direction and conduct of our profession.

Optomyometer. A device used in measuring the power of the ocular muscles.

Optona. One of the many pernicious quack remedies, of the "Murine" class, advertised in the public prints. Along with a sermon on the ineffectiveness and harmfulness of glasses is generally published a statement of the wonders of this remedy, a tablet of which dissolved in water and used as an eye-bath will benefit "weak" eyes, sore lids and even cataracts. The word "cure" is absent, no doubt for reasons of legal safety to the advertiser, but the public is assured of "clear, healthy, strong magnetic eyes" through the use of the remedy.

Optophone. An instrument devised by Fournier d'Albe (*Scientific American Supplement*, August 3rd, 1912), of Birmingham, designed to enable "totally blind persons to recognize, locate and even measure the amount of light by means of the ear." The apparatus employed is essentially a telephone into the circuit of which a cell of the element selenium has been introduced. This substance has the peculiar property of being very resistant to the passage of the electric current when in the dark, and of transmitting it readily in the light. The optophone is so constructed that the selenium cell is screened from the light except as admitted through a narrow tube. When this tube is directed toward the light, the current passes, and the holder of the telephone hears a buzzing or whirring sound. But when the tube is directed toward a dark object, the current is obstructed, and the sound in the receiver ceases or is weakened. The experiments which have been made with the optophone, have been picturesquely, if not quite accurately, referred to as "making light audible." See, also, **Selenium** and **Phonopticon, Crystal.**

Optoscope of Bertin-Sans. See p. 944, Vol. II of this *Encyclopedia.*

Opto-technics. The technical applications of the science of optics.

Optotype. A letter or other character of a definite size selected as a test for the acuteness of vision; test types of various sizes, as those of Snellen and Landolt, which are made to embrace a visual angle of five minutes at different distances. See p. 2016, Vol. III of this *Encyclopedia.*

Orange light. See **Colors of signals,** p. 2473, Vol. IV of this *Encyclopedia.*

Ora serrata. The anterior dentated margin of the retina along the edge of the ciliary processes of the choroid. See **Anatomy of the eye**; as well as **Histology of the eye.**

Orbicular. ORBICULATE. ORBICULATED. Of the shape of an orb or orbit; spherical or circular.

Orbicularis. A shortened term often used for the orbicularis palpebrarum muscle.

Orbicularis inferior. The fibres of the orbicularis palpebrarum supplied to the lower lid.

Orbicularis internus. The palpebral portion of the orbicularis palpebrarum.

Orbicularis malaris. The outer and most inferior part of the palpebral portion of the orbicularis palpebrarum.

Orbicularis oculi. A name for the orbicularis palpebrarum muscle.

Orbicularis oculi palpebralis inferior. The portion of the orbital part of the orbicularis palpebrarum lying along the lower margin of the orbit.

Orbicularis oculi palpebralis superior. The portion of the orbital part of the orbicularis palpebrarum lying along the upper margin of the orbit.

Orbicularis orbitæ. The orbital portion of the orbicularis palpebrarum.

Orbicularis palpebralis. ORBICULARIS PALPEBRARUM. The muscle surrounding the circumference of the orbit and eyelids.

Orbicularis palpebrarum centre. A centre supposed to be situated near the angular gyrus.

Orbicularis palpebrarum muscle. See p. 345, Vol. I of this *Encyclopedia.*

Orbicularis palpebrarum reaction. GIFFORD-GALASSI REACTION. WESTPHAL-PILTZ REFLEX. This phenomenon, described on p. 5327, Vol. VII and elsewhere in this *Encyclopedia,* is a contraction of the pupil when an effort is made forcibly to close the eye. Gifford regards it as an overflow stimulus passing from the nucleus of the facial to the third nerve along the longitudinal fasciculus of Mendel.

Orbicularis palpebrarum muscle, Diseases of. See the various headings beginning with **Blepharo—,** mostly in Volume II of this *Encyclopedia;* **Lagophthalmos,** p. 6992, Vol. IX; as well as **Facial nerve** and **Facial paralysis,** p. 5136, Vol. VII.

Orbicularis palpebrarum, Paralysis of. See **Lagophthalmos,** Vol. IX, p. 6992 of this *Encyclopedia;* also **Facial paralysis,** p 5136, Vol. VII.

Orbicular pupillary reaction. A term referring to contraction of the pupil when a forcible effort is made to close the lids. Gifford-Galassi reflex.

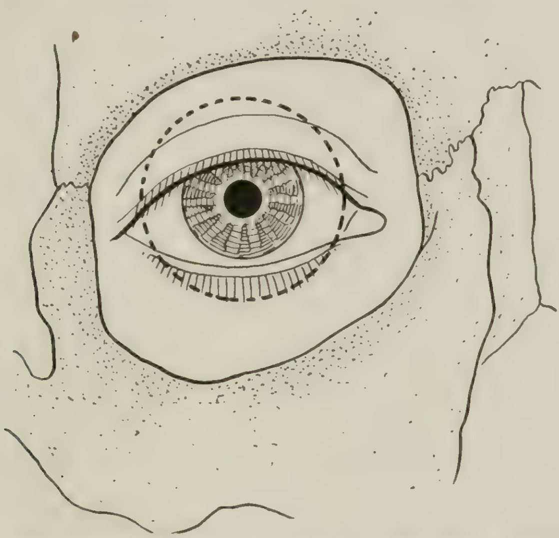
Orbicular space. A name given by Garnier and Salzmann to the most peripheral and most posterior part of the posterior chamber, a narrow cleft which is between the inner surface of the *orbiculus ciliaris* and the corresponding area of the anterior marginal layer of the vitreous.

Orbiculus capsulo-ciliaris. A name for the zonule of Zinn.

Orbiculus ciliaris. The ciliary body and ligamentum pectinatum.

Orbiculus ligamentosus (ciliaris). The ciliary muscle.

Orbit. Orbital cavity. In addition to the anatomic description and illustration of this space given on p. 401, Vol. I of this *Encyclopedia*, there may be added the observation of Rosseau (*Ophthalmic Year-Book*, p. 302, 1916). He thinks the anatomy of the *unstriated muscle fibers of the orbit* is but little known. In order to get a correct idea of the topography and importance of these unstriated muscle fibers it is necessary to study series of entire orbital sections, frontal and sagittal combined. Effective staining, specific for the unstriated muscle fibers should be employed.



Relations of the External Eye and Eyeball to the Orbit. (After Merkel.)

We can affirm the existence of a certain number of formations: (a) The palpebral unstriated muscles of Müller. (b) The inferior orbital muscle, which in man is of the thickness of a layer of unstriated muscle, and which we find in the lower animals in the form of a sheath. (c) A peribulbar muscle formed by the sagittal fibers; but mostly frontal (circular muscle) and which extends but little beyond the equator of the globe. (d) Formations of unstriated muscular fibers in the extremity of the lateral recti muscles.

It is impossible after complete critical study to attribute to these muscular fibers the important pathological rôle that some wish to accord them, viz.: (1) Venous stasis by compression of the superior and inferior ophthalmic veins by the superior orbital muscle; and (2) the

protrusion of the globe in exophthalmic goiter through stimulation of the sympathetic, the motor nerve of the periorbital unstriated muscle fibers.

Orbital axes. In most Aryan races the crossing of the axes behind makes an angle of about 42° which corresponds, of course, to 20° with the median plane of the head. The basis of the orbital pyramids do not lie exactly in the same frontal plane, but make with one another an angle that varies greatly in individuals but strikes an average of 147° in men; slightly less in women.

The size of the orbit varies greatly according to the age, sex and racial origin of the individual. Czermak gives the following averages for Europeans:

Depth of the bony cavity,	39.4 to 50 mm.
Men	43 mm.
Women	40.55 mm.
Width at the base, men	40.5 mm.
Width at the base, women	40 mm.
Height of the facial opening, men	35 mm.
Height of the facial opening, women	34.5 mm.
Distance between the orbital axes at the base of the orbit	62 mm.

To calculate the depth of the orbital cavity on the living subject the same author advises the measurement of the space between the first upper molar tooth and the posterior aspect of the wisdom tooth, which corresponds to the length of the inner orbital wall.

The periosteum covering the orbit is thin and delicate. It not only lines the various openings that lead into or out of it but becomes one of the coverings of the nerves and blood-vessels that pass through them. These include the optic foramen and the superior orbital fissure which, communicating with the cranial cavity, are continuous with the dura mater. In the same way this periorbital membrane extends through the floor of the cavity to the temporal fossa and pterygopalatine and by way of the lachrymal duct to the nose. As a rule the orbital periosteum is very loosely attached to its bony surroundings Only in the region of the sutures, the orbital openings and on the margins of the cavity is it closely applied to the osseous structures—a fact that should be borne in mind in operations involving this tissue. It must be remembered, also, that it sends fibers into and about the soft tissues that fill the orbit—the muscle fascia, the fat bundles, nerves and blood-vessels.

W. Krauss (*Münch. Med. Wochenschr.*, Sept. 19, 1911), believes, also, that in the deeper portions of the human orbit a system of smooth musculature exists (membrana orbitalis musculosa), which so far has been overlooked, satisfying all anatomical requirements necessary to explain acute and chronic changes in orbital volume. See, also, **Capacity of the orbit**, p. 1386, Vol. II of this *Encyclopedia.*

Orbit, Abscess of the. PHLEGMON OF THE ORBIT. ORBITAL THROMBOPHLEBITIS. ORBITAL CELLULITIS. PERIOSTITIS OF THE ORBIT. CARIES OF THE ORBITAL WALLS. OSTEOPERIOSTITIS OF THE ORBIT. NECROSIS OF THE ORBIT. In addition to the account of orbital cellutitis given on p. 1924, Vol. III of this *Encyclopedia* it may be added here that, owing to the undeveloped condition of the accessory sinuses in children—to the extension from which most forms of orbital cellulitis are due—very few cases of orbital cellulitis are known in patients under 9 years of age. W. C. Posey (*Jour. Am. Med. Assocn.*, Sept. 21st, 1912) reports two cases (one in a child a year old; another two years of age) in which the orbital disease arose from septic conditions in the nasal sinus.

Heckel states that orbital cellulitis, arising from causes other than sinusitis, does not necessarily lead to suppuration or abscess formation. It may result in a temporary exophthalmos caused by an inflammation and edema. Other causes are: trauma, carious teeth, osteomyelitis, facial erysipelas, meningitis, brain abscess, exanthemata, operations on the eye muscles, continued fevers, metastasis and actinomycosis. Hosford points out that orbital disease is more common on the left than the right side. A large percentage of swelling of the inner half of the orbit is due to acute or chronic collections in the ethmoid, frontal and sphenoidal sinuses, and to necrosis of the lamina papyracea. More than one half the cases of orbital cellulitis arise from disease of the inner wall of the orbit, proptosis is generally downward, outward and forward. Septic processes which spread from the antrum and perforate the orbital plate of the superior maxillary are less successfully treated than extension from the ethmoids. He describes a bilateral thrombosis of the cavernous sinus, the circular sinus and ophthalmic vein containing septic matter, in a child 6 weeks old.

Birch-Hirschfeld reports the clinical histories and results obtained in three cases of chronic and twelve cases of acute inflammation of the orbit. From a girl of 8 with intense exophthalmos, normal eyeball and vision, a retrobulbar malign tumor was diagnosed and partly removed by Kroenlein. Two months later the orbit was exenterated and tubercle bacilli found in the tissues. In a woman of 52 the exophthalmos was probably produced by chronic gummatous inflammation. An exophthalmos caused by mucocele of frontal and ethmoidal sinuses was cured

by opening the ethmoidal cells. An orbital injury was followed by intense swelling, high fever, somnolence, vomiting, restriction of ocular movements and impairment of vision. Incisions produced pus containing the staphylococcus pyogenes aureus. The general condition growing worse, exenteration of the orbit was done, and resulted in recovery.

Six cases were due to inflammation of accessory sinuses, two of frontal, three of the ethmoidal and one of the maxillary sinus.

Two cases were of metastatic subperiosteal abscesses resulting after bronchitis and tonsillar abscesses. Incision of chalazion was followed by purulent tenonitis; and a woman of 60 developed orbital phlegmon after incision of hordeolum on the lower lid.

Hertel (*Oph. Year-Book,* p. 304, 1913) demonstrated the orbital contents, including the eyeball, of a case of thrombophlebitis, following a furuncle of the nose. This patient had a high fever and was slightly somnolent. A free incision was made into the furuncle and along the lower orbital margin; the periosteum was elevated but no deep abscesses were found. After amelioration for three days, fever reappeared and the cheek became phlegmonous. After exenteration of the orbit the patient felt better, subjectively; but the abscess of the cheek became larger, entering the oral cavity and the floor of the mouth, death ensuing four days later. The autopsy revealed abscess of the face, encroaching on the meningeal vessels and the cavernous sinus of both sides. The staphylococcus pyogenes aureus was found in the orbital contents.

An unusual case of *orbital osteoperiostitis* is reported by Almeria Marin (*Arch. de Oftalmologia,* Sept., 1915). The patient, a boy of six years, developed at the same time a purulent discharge from the external auditory canal, which apparently came from a deep swelling in the temporal region, and a severe osteoperiostitis of the inner side of the left orbit. There was high fever, exophthalmos, and severe pain. After opening the orbital abscess with a bistoury the periosteum of the inner wall of the orbit was found to be completely detached from the os planum of the ethmoid, which was in part destroyed. A temporary interruption of drainage from the orbital focus was accompanied by a marked increase in the discharge from the ear. After about two months' treatment the patient was discharged cured, the eye itself being unharmed. Two years and four months later the patient returned on account of a repetition of the orbital abscess of the left side. Again, after opening the abscess with a bistoury, the periosteum was found to be completely separated from the inner wall of the orbit. The pus was found to contain the streptococcus, and the patient's recovery was apparently hastened by injection of antistrepto-

coccic serum. The duration of treatment for this attack was thirty-four days, and the patient was again discharged without having suffered any direct ocular lesion. The author considers the simultaneous occurrence of the orbital abscess and of the abscess which discharged through the external auditory canal as having been due to a deep subperiosteal communication by way of the sphenomaxillary fissure and the temporal fossa.

Col. W. T. Lister (*Br. Med. Jour.*, Mar. 6, 1915), in an account of *enucleation in the presence of orbital cellulitis*, remarks that it is well known that to remove an eye in which there is panophthalmitis and an open wound in the globe is a risky procedure, and liable to be followed by septic meningitis if carried out in the ordinary way with division of the optic nerve.

To avoid this serious complication some surgeons merely eviscerate the globe and leave the sclerotic to shrink up, a process which, as a rule, takes about a fortnight or even longer. Others first eviscerate the eye, then, after carefully washing the sclera and conjunctiva, to remove, as far as possible, all septic matter, proceed to remove the sclerotic. In this way the process of healing is greatly shortened, and much less risk of infection of the sheath is run.

In dealing with eyes which have been penetrated or ruptured by bullets or large foreign bodies, there is usually orbital cellulitis more or less severe as a complication. In these cases it would seem that still greater risk of infection of the sheath of the optic nerve might exist, which in turn could easily be followed by meningitis, if the remains of the eye be removed in the ordinary way with division of the optic nerve, and consequently opening of its sheath.

In order to prevent infection of the nerve sheath the following plan appears to be a good one: (1) The contents of the globe are thoroughly eviscerated, all traces of retina and choroid being scraped away to avoid any chance of sympathetic ophthalmia. (2) The muscles are divided. (3) The sclerotic is pulled forward and divided far back, leaving only a frill round the intact optic nerve. The actual procedure may be varied according to the following circumstances: (a) when the opening in the globe is small, or has firmly healed, the conjunctiva and muscles are divided first, as this is, of course, much more simply done while there is some tension in the globe. The cornea is then cut away and the contents of the eye carefully scraped out, either with a large sharp spoon or a scoop made for the purpose, and the process completed by scrubbing out the sclera with a swab held in a pair of forceps. The sclerotic is drawn well forward by two or three pairs of pressure forceps, and cut far back, leaving a frill round the nerve as

described above. (b) If the globe has an open rent or wound the contents should be scraped out first and the shell of sclerotic and conjunctiva thoroughly washed. The sclerotic is now packed firmly with a strip of gauze to facilitate the division of the muscles, which is next performed. The gauze is now removed, the sclera drawn well forward and divided as before. (c) Where the globe is split open in all directions, as is often the case when a bullet has passed through it, packing is impossible. In this case, after scooping and wiping out the contents of the eye, the separate portions of the sclera can be picked up and made taut with pressure forceps and the muscles dissected off as far back as possible. After drawing the bunch of forceps forward the sclerotic is now cut through, as described above.

The three points to be kept in mind are: (1) To remove all trace of retina or choroid; (2) To take away the bulk of the sclerotic, but (3) To leave a frill of sclerotic round the intact optic nerve. In this way all risk of infection of the nerve sheath and the meninges as the result of the operation is avoided; there is very little bleeding, the shock due to cutting the optic nerve does not occur, drainage for the cellulitis is afforded, and the healing process is not prolonged by leaving in the bulk of the sclerotic.

The same procedure would, it seems, be the safest method of removing eyes with panophthalmitis.

The above simple method may have occurred to and been practised by many, but, so far as known, is not in general use. The results are good, and this slight deviation from the usual procedure seems sufficiently valuable to justify the publication of a short note in the hope that it may prevent an uncommon but disastrous complication at a time when so many eyes have to be removed in the presence of orbital cellulitis.

A number of cases of death have occurred from *orbital cellulitis.* Hansell (*Pr. Med. Series*, Eye, p. 108, 1908) has reported two of these. The first was that of an Italian baby of 4 months, who developed an orbital cellulitis, without known cause, which terminated in death from general erysipelas. The autopsy showed the accessory nasal cavities to be normal. His second was a lad of 13 years who developed an orbital cellulitis following a blow on the right eye with an icy snowball. Pus was liberated from the orbit and the interior cerebral fossa by operation, but death followed two days later.

Let us now consider briefly the surgical treatment of orbital abscess.

An incision should be made with a long, straight bistoury—by preference through the conjunctiva. If, on account of swelling and edema, this should be impracticable, the incision can be made through

the upper lid. The knife should pass close to and parallel with the orbital wall, avoiding the eyeball and the optic nerve. The opening of the incision should be freely enlarged, a bichlorid-of-mercury solution (1 to 3000) should be carefully introduced by syringing, and drainage should be maintained by loose packing. The general treatment is tonic and supportive. Good diet, iron, quinin, strychin, and alcohol in the form of milk punches are indicated.—(J. M. B.) See, also, **Cavities, Accessory**; and **Cavernous sinus.**

Orbit, Actinomycosis of. See p. 84, Vol. I of this *Encyclopedia.*

Orbit, Adenoma of the. This neoplasm does not appear as a primary growth except (rarely) in connection with the lachrymal gland. Then it is most commonly seen as a simple hypertrophy of the gland, which may, indeed, reach considerable size. Only the microscope will furnish a sure diagnosis.

Orbital aponeurosis. Tenon's capsule. A fibrous tissue in the orbit which gives off prolongations that cover the muscles, pass into the eyelids, and extend over portions of the eyeball.

Orbital artery. A small vessel arising from either the superficial or middle temporal artery, which runs forward across the zygoma to supply the outer portion of the orbicularis palpebrarum muscle and integument.

Orbital cellulitis. See **Orbit, Abscess of the.**

Orbitale. The lowest point of the inferior edge of the orbit.

Orbital fascia. See under **Orbit.**

Orbital fat, Hernia of. See p. 5879, Vol. VIII of this *Encyclopedia.*

Orbital hemorrhage. See **Orbit, Hemorrhage into the,** and p. 5797, Vol. VIII of this *Encyclopedia.*

Orbital heteroplasty. A name given to the transplantation of animal eyes into the human socket as a substitute for Mules' operation. See p. 4469, Vol. VI of this *Encyclopedia.* Bonnefon (*Year-Book,* p. 308, 1912) describes the following method: A rabbit of medium size is killed and the eyeball enucleated, saving as much of the muscles and optic nerve as possible. Under general anesthesia, the eye of the patient is enucleated, and all hemorrhage completely stopped. Sutures with double armed ends are then passed vertically and horizontally through the muscle and nerves of the rabbit's eye, which has been preserved in a sterile salt solution. After the cavity of Tenon's capsule has been thoroughly washed with hydrogen peroxid and dried, the rabbit's eye is placed therein, cornea downwards, the needles passed through the tendons of the corresponding sides and tied with double knots to bring the corresponding ends of the recti in apposi-

tion. The conjunctiva is then sutured over this. The results of this operation have always been satisfactory, provided strict asepsis is observed and no infection takes place.

Orbital index. The height of the orbit multiplied by 100 and divided by its width. If the dividend be above 89 it is called *megaseme,* if under 84, *microseme* and, if between the two, *mesoseme.* See **Broca's orbital index,** p. 1311, Vol. II of this *Encyclopedia.*

Orbital thrombophlebitis. See **Orbit, Abscess of the.**

Orbit, Aneurism of the. See p. 461, Vol. I, as well as p. 4860, Vol. VII of this *Encyclopedia.*

Orbit, Angioma of. See p. 466, Vol. I of this *Encyclopedia.*

Quackenbos (*Annals of Ophthalm.,* Oct., 1908) reports the clinical history of an angioma of the orbit in a man, æt. 32, who had noticed a few dilated vessels in the conjunctiva of the lower lid of his left eye since infancy. The temporal portion of the ocular conjunctiva also showed the same condition. At the age of 12 the angioma suddenly increased in size, resulting in swelling of the lower lid and exophthalmos. The process then remained quiet until he was 23, when the lower lid became more swollen. Electrolysis was used when another period of rest followed for 6 years, only to be attended with renewed activity. The swelling now extended to the upper lid and the eye was more proptosed, when difficulty in closing the lids was experienced. Gradual increase of the symptoms continued until the cornea became ulcerated from exposure. Until this time the vision remained almost normal. The eyeball together with the tumor was removed by Quackenboss, the entire mass being about the size of a goose-egg. Nine months after the operation there had been no recurrence. An extended report of the pathologic findings is presented by F. H. Verhoeff, his diagnosis being hemangioma of the orbit with invasion of the ciliary nerves, sclera, cornea, choroid and optic disc.

Orbit, Auscultation of the. See p. 699, Vol. I of this *Encyclopedia.*

Orbit, Carcinoma of the. In addition to what is said on p. 1412, Vol. II of this *Encyclopedia* it may be added here that Genet (*Révue Gén. d'Ophtal.,* Feb., 1913) reports a case extirpated by his socalled *curvilinear external orbitotomy,* fully described under **Orbit, Operations on the.**

The cancer of the orbit was metastatic, following a breast amputation in which histologic findings showed carcinoma. Patient was 55 years of age, and had exophthalmos for nineteen months, with headache, diplopia and marked conjunctival chemosis. Disc showed only swollen veins, otherwise normal. A tumor mass palpated behind and to the side of the globe. Under general anesthesia the operation de-

scribed by Rollet was performed, with the following technic: Lid sutures enclosed the eye in its conjunctival sac to prevent ulceration of the cornea and to facilitate the deep examination of the orbit. Incision made over the bony margin 3 centimeters in length. Aponeurosis was split at its concave border. Exploration with finger was easier without preliminary osteotomy, because of broken bone fragments. The tumor is then shelled out if limited and seized with a toothed forceps. Rollet has also devised two retractors which allow a view deep into the orbit. On the eighth day the chemosis had disappeared and only a sluggish suppuration retarded a complete recovery.

This method has been used thirty times in the eye clinic at Lyons, and is preferred to all other operations. It is not followed by a ptosis, no extrinsic muscles are severed. The conjunctival sac remains intact. There is sufficient space in which to work and the operation is easily performed.

Cords has also reported a case of carcinoma of the orbit, originating in the caruncle. The patient, a man of 55 years, gave a history of having been injured in the eye with a straw, a year before the tumor was first noticed. Four years had elapsed since then. At operation the tumor, which was of cartilaginous consistency, was found to extend from the crista lacrimalis and the inner half of the upper orbital margin deep into the orbit.

Orbit, Caries of. See **Orbit, Abscess of the**; also p. 1426, Vol. II of this *Encyclopedia.*

Orbit, Cellulitis of the. See **Orbit, Abscess of the.**

Orbit, Chloroma of. See p. 2026, Vol. III of this *Encyclopedia.*

Orbit, Chondroma of. See p. 2118, Vol. III, as well as p. 1431, Vol. II of this *Encyclopedia.*

Orbit, Congenital anomalies of. See **Cyclopia,** p. 3641, Vol. V, as well as p. 2812, Vol. IV of this *Encyclopedia.*

Orbit, Congenital cysts of. See p. 3694, Vol. V of this *Encyclopedia.*

Orbit, Contusion of. See **Orbit, Injuries of the.**

Orbit, Cylindroma of the. See p. 3659, Vol. V of this *Encyclopedia.*

De Obarrio (*Ophthalmoscope*, March, 1913) reports a large cylindroma of the orbit operated on without tenotomies, bone resection or opening of the conjunctiva, with preservation of the eye in its entirety, together with all its functions. The patient, a male of Indian extraction, 20 years of age, showed a marked exophthalmos of the left eye with a decided deviation directly downwards in a vertical plane, to the extent of about three-quarters of an inch below the level of the right pupil, and a very small outward deviation as well. The upper lid was very prominent, but without any inflammatory appear-

ances, and it had the consistency of a lymphoma. The lower lid, on the contrary, was very much crowded and wrinkled. The palpebral conjunctiva was normal. The bulbar conjunctiva presented marked engorgement of its vessels, principally the veins, due to the compression. There was no loss of sensibility in any part of the organ. The cornea, iris, lens, and vitreous were normal. The optic disc was hazy, and presented marked vasodilatation, such as might be expected from compression.

Vision, 20/40, with a very irregular astigmatism from his corneal opacity as well as from the change of form due to the compression. His sight was, however, most affected from the compression of the optic nerve. Motility: The eye was practically fixed in the orbit, permitting only very slight motion in every directon except upwards. Pupillary reaction to light, convergence, and accommodation was very sluggish.

On palpation the whole of the tumefaction of the upper lid was of an even consistency. A very small, hard, unyielding projection could be felt at the upper orbital margin lying within the orbit. There was no pulsation.

Under general anesthesia a large curved incision was made down to the bone parallel to the orbital margin, extending from the inner angle to the outer. A roughly oval-shaped encapsulated tumor, almost as large as a hen's egg, lying horizontally from before backwards in the orbital vault, with the small end forwards, and four-fifths of its bulk posterior to the equator of the eyeball, was separated by blunt dissection from the muscles, periosteum and optic nerve and extracted in its entirety. Pathologic examination showed a mixed neoplasm having three distinct elements, to which the name was given "myxo-lymphango-endothelioma," which is a cylindroma. It resembled very much such mixed tumors as are observed in the parotid gland.

The patient made a good recovery. Functional examination, thirty days later, was perfect with the exception of the vision, which was 20/50, owing to optic nerve condition. The motility, convergence, and esthetic result were unusually good. After a lapse of two years, there has been no recurrence.

Orbit, Cysticercus of the. See p. 3661, Vol. V of this *Encyclopedia*.

Orbit, Cysts of the. See p. 3694, Vol. V of this *Encyclopedia*.

Rumszewicz (*Ophthalmic Year-Book*, p. 305, 1913) describes the histologic examination of a large orbital cyst, which was situated between the orbital wall and the periosteum. Within an oblong capsule a number of cystic spaces were found which were lined with flattened epithelial cells containing numerous fat globules. The contents of the

cysts comprised flat concentric layers of cells without nuclei between which fat detritus and cholesterin cells were found. In another case the eye was proptosed forward and downward. The cause of the exophthalmos was a cyst lined with endothelial cells containing a serous fluid. Rumszewicz also describes two dermoid cysts of the orbit, the first occurring in a girl of 16. Extirpation of the cyst showed it to be adherent to the fronto-zygomatic suture by means of a fine thread. The second case which was in the inner part of the orbit also had a cord-like adhesion between the cyst and the fronto-ethmoidal region. The contents were the usual material found in dermoid cysts.

Posey also reports a chronic cystic and giant-cell formation in the floor of the orbit, and connected with the lachrymal sac, which arose after false passages of lachrymal probes. Examination revealed a swelling the size and form of a small butternut in the lower and inner part of the orbit, which gave the impression of a bunch of small angle-worms to the fingers. Firm pressure elicited crepitation and caused the swelling to disappear. Operation revealed a mass studded with numerous small cystic elevations, which cracked under the fingers. No trace of the tear sac was found.

Orbit, Dermoid cyst of. See p. 3844, Vol. V of this *Encyclopedia*. A number of these benign tumors are described in the literature of the subject. For example, Bogatsch (*Ophthalmic Year-Book*, p. 374, 1912) from the right orbit of a youth of 17 years removed a large dermoid cyst. The eye had protruded somewhat since birth, but much more within the last eight years. Rumszewicz has reported two cases of teratoma, the growth in each instance being deep in the orbit and associated with the bony wall of the orbit by connective tissue bands. Histologically the tumors were found to contain neuroglia cells, hairs, smooth muscle cells, and cartilaginous and bony tissue. (See supra.)

Orbit, Development of the. See p. 3868, Vol. V of this *Encyclopedia*.

Orbit, Echinococcus of the. See p. 4123, Vol. VI of this *Encyclopedia*.

Orbit, Edema of the. Maklakow relates a case of recurrent edema of the orbit beginning with sudden sharp pain, swelling of the lids, redness of the eyeball, fever, shivering and great heat in the eye. Six or seven hours later vomiting and diarrhea ensued, while the swelling of the eye gradually diminished. Every year or two either the right or left eye was affected, but while the right eye had full vision, the left eye had become atrophic. The author classes these cases as a form of Quinke's disease or angioneurosis, optic atrophy being a sequel.

Another case, somewhat different in its clinical aspects, is reported by J. J. Wynn (*Jour. Oph. Otol. and Laryng.*, Sept., 1915). A woman, aged 45, passing through the menopause, was an asthmatic and had

erythema nodosum on chest and abdomen. In the fall of 1913 she had a first attack of swelling, involving orbits, face and forehead. Four similar attacks took place before her vision began to fail. It was found that she was developing an optic atrophy which went on from bad to worse with every attack of orbital swelling, until only moving objects were seen. These attacks had all the clinical appearances of erysipelas and had it not been for the erythema nodosum would have been so diagnosed.

Orbit, Emphysema of the. When, as the result of injury, the naval air spaces communicate with the cavity of the orbit emphysema of the orbital tissues is a symptom. See p. 4302, Vol. VI of this *Encyclopedia.*

Orbit, Enchondroma of the. See p. 4307, Vol. VI, as well as p. 2118, Vol. III and p. 1431, Vol. II of this *Encyclopedia.*

Orbit, Endothelioma of the. See p. 4312, Vol. VI of this *Encyclopedia.*

Orbit, Exenteration of the. See **Orbit, Operations on the.**

Orbit, Exostoses of the. See p. 4875, Vol. VI of this *Encyclopedia.*

Orbit, Fibroma of the. See p. 5186, Vol. VII of this *Encyclopedia.*

Roy (*Annales d'Oculistique*, July, 1908) reports a calcifying fibroma of the orbit in a boy 14 years of age, without syphilitic, tuberculous or other diathesis. Three years before he came under the observation of Roy he complained of pain in the left eye and impairment of vision, and these symptoms were followed by exophthalmos.

A tumor the size of a ''nut'' was removed from the orbit, and the pain continuing the ball was enucleated. Two years later there were swelling of the orbital tissue and severe pain and headache, and a sanious discharge flowed from the orbit.

A large tumor filled the orbit and extended beyond its upper margin, and when removed was found to consist of a fibroma with numerous small foci of calcification.

In a case described by Teulières, the patient, a woman of 34 years, had a fibroma arising from the periosteum beneath the upper orbital margin which had been caused by a violent blow. The tumor was easily removed through an incision in the upper lid.

A fibroangioma of the orbit was removed by Otto Schirmer (*Am. Medicine*, March, 1913). A temporary resection of the temporo-orbital wall by the Kroenlein method was decided upon. A big flap formed of skin, muscle and bone was turned outward. A smooth, firm tumor attached by a small pedicle to the inner orbital wall was discovered and was detached and delivered in toto. A year later the scar was scarcely visible, the position of the eye normal, mobility nearly perfect and the sight normal.

Orbit, Filaria of the. See **Filaria**; as well as p. 5195, Vol. VII of this *Encyclopedia.*

Orbit, Fistula of the. This formation is generally the result of caries or necrosis of some portion of the orbital walls, and it may persist for years until the underlying cause is removed. See **Orbit, Abscess of the,** as well as p. 1426, Vol. II of this *Encyclopedia.*

Orbit, Foreign bodies in. See **Orbit, Injuries of the,** as well as p. 5268, Vol. VII of this *Encyclopedia.* To the matter found there a few illustrative paragraphs may be added.

Black's Case of Foreign Bodies in the Orbit.

Edward Stieren (*Ophthalmic Record,* Sept., 1913) believes that foreign bodies in the orbit need not be disturbed if they are of steel or lead. Copper and brass, glass and wood, are apt to be troublesome. Unless there is urgent demand for its removal, the foreign body is best allowed to remain in the orbit owing to the difficulty of finding it, even when localized, and the possibility of damage to muscles, nerves, or vessels in the search for it. When absolutely necessary, such a search is better done by a free incision through the palpebral skin, rather than through the conjunctival fornix which gives but a limited field in which to work.

The history of a foreign body in the orbit for four years is furnished by Packley (*Austral. Med. Gazette,* June, 1906). In 1902, while at play, a small boy was knocked against a rail fence and fell with another boy on top of him. Immediately afterwards he pulled a splinter of hardwood "out of his right eye." There was only trifling bleeding. For two days afterwards he had headache and occasional retching. On

recovering from the momentary concussion he discovered he had no perception of light in the right eye, and that the ball had protruded somewhat. When first seen, eight days after accident, the right eye was proptosed, and there was a small cicatrix on the cheek below and slightly to the nasal side of the eye. Tenderness on pressure in the orbit below the eye, not elsewhere; there was an offensive smell from the eye. Ophthalmoscope showed great swelling and tortuosity of the veins near the disc. A conjunctival incision was made midway between the inferior oblique and inferior rectus, and in exploring through this incision, a hardwood splinter, ¾-inch long and 3/16-inch thick, was drawn out with forceps. Careful probing revealed no other foreign body. There was little pus around the foreign body, but the wound was cleaned and left open with a gauze drain for a few days.

A week later the eye had gone back nearly to its normal position. No pain or tenderness on pressing back into the orbit. Optic neuritis was much more marked. No light perception. Disc eventually passed into a condition of white atrophy, and when last seen a few weeks after the accident, the eye was quite normal in position and movement, and no pain or tenderness.

Four years later the patient's mother brought in specimen No. 2, a piece of wood 1¼ inches long and ⅛ inch thick, which the boy had found "sticking out of the corner of his eye" on waking, a few days before. There had been no pain or swelling previously, and nothing had been noticed when he went to bed the night before. The dentations on the end of the second piece exactly fitted those on the end of the first piece.

Cases are on record of large foreign bodies being lodged in the orbit without the patient's being aware, but not (up to this report) for so long a period as four years. If a foreign body be aseptic and causes no inconvenience for some weeks, there is no reason why it should not remain for an indefinite period. In this case, however, the foreign body was septic, and caused suppuration, and yet after removal of the first piece the remaining portion lay quiet for years.

H. E. Randall (*Ophthalmic Record*, July, 1910) reports the following case of a splinter of wood in the orbit for fifteen years. H. P. was injured about the head in the lumber woods fifteen years ago, i. e. in 1895. While removing sawdust from a shingle-saw he was hit in the eye by something that dazed him for a moment; after which he entirely recovered consciousness but was nauseated and eventually vomited. He thought he had been struck a glancing blow by some blunt instrument that "broke his malar bone," but the wound healed promptly. He subsequently noticed that his lip and part of his cheek

lost the sense of feeling and this partial loss has been permanent. The last named symptom was the only one noticed about the eye until five years ago when the old scar and the surrounding tissues became red after taking iodid of potassium which had been ordered for an attack of syphilis acquired subsequent to the injury. As soon as the medicine was stopped the inflammatory signs disappeared, but when he resumed the remedy they returned. Finally, the wound area became swollen, broke down and discharged some pus. The sinus thus opened did not heal and it was in consequence of this state of affairs that he presented himself for treatment.

The fistulous opening, which had persisted for two years, was closed by the following procedure:—An incision, opening up the sinus, was made, the finger was introduced into the opening and a splinter of wood about two inches in length was felt and removed. The scar tissue around the opening was excised and two stitches completed the operation—after which the wound promptly healed. The foreign body proved to be a cedar splinter of the wood used in Michigan fifteen or twenty years ago for the making of shingles. This sliver had probably been in the orbital cavity since the date of the original injury.

Orbit, Fracture of the walls of the. See **Orbit, Injuries of the,** as well as p. 5282, Vol. VII of this *Encyclopedia.*

Orbit, Gliosarcoma of the. This tumor results from an extension of a neoplasm from the optic nerve or retina.

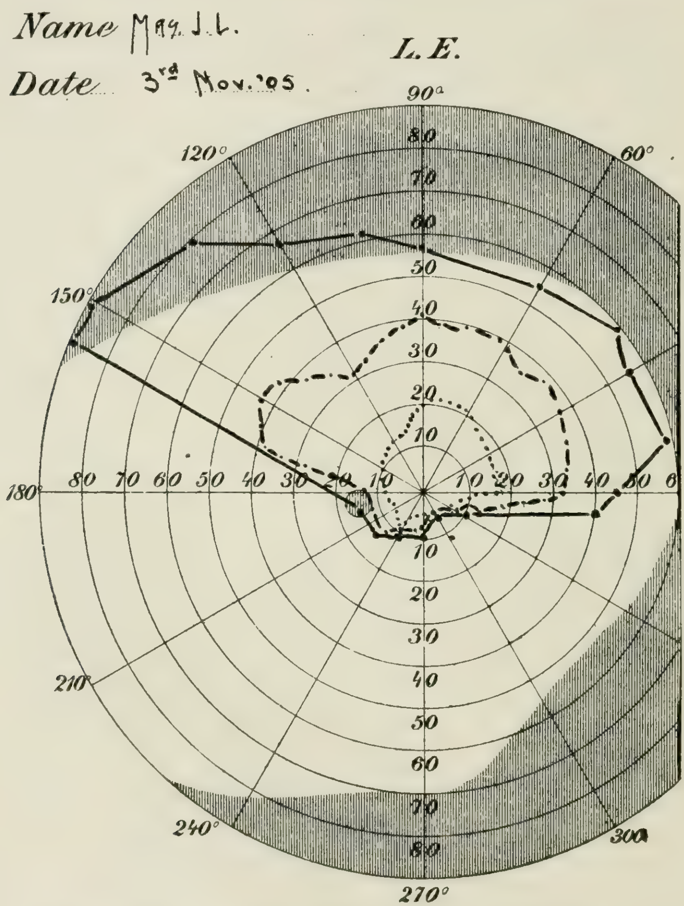
Orbit, Gumma of the. See p. 5661, Vol. VII of this *Encyclopedia.*

A case is reported by Reese (*Ophthalmic Year-Book*, p. 309, 1916) which had produced vascular changes resulting in what he thought was an arteriovenous aneurysm between the internal carotid artery and the cavernous sinus. The patient's predominating symptoms were headache and exophthalmos, more pronounced on the right side, and buzzing noise in the right ear. Examination revealed a right-sided choked disc, eccentric exophthalmos, concentric contraction of the visual field and 20/200 vision. The left fundus showed only tortuous veins, vision and field being normal. The conjunctiva of the right eye was chemotic. Pressure would reduce the exophthalmos but not without pain. No bruit could be heard. Blood examination revealed a positive Wassermann reaction. Sixteen injections of neosalvarsan, and as many of salicylate of mercury were given. This was followed by inunctions of mercury and potassium iodid internally. The exophthalmos receded 3 mm. A systolic bruit could now be heard over the bones of the skull. There were tortuous venous swellings in the upper portion of the orbit, which pulsated. Pressure on the right carotid produced no effect on the exophthalmos or bruit; pressure over the

left carotid caused a disturbance of the bruit. Distention of the transverse and circular sinuses is probably responsible for the venous engorgement of the left side.

Orbit, Hemangioma of the. See p. 5756, Vol. VIII of this *Encyclopedia*.

Orbit, Hemorrhage into the. Hematoma of the orbit. In addition to the information to be found on p. 5797, Vol. VIII of this *Encyclopedia*,



Field of Vision in Tooke's Case of Orbital Hemorrhage.

it may be added under this caption that intraorbital hemorrhages may be divided, according to Tooke, into two groups: traumatic, and non-traumatic or spontaneous. In the traumatic variety the blood effusion may be an extravasation between the loosened periosteum and the bony wall of the orbit; or, again, the hemorrhage may occur

into the orbital cellular tissue; or, lastly, within what we understand as the oculo-orbital fascia, or capsule of Tenon. In the site last mentioned we find those hemorrhages which have been reported as following operative interference for the relief of squint. Severe blows on the orbit, resulting frequently in fracture of the orbital wall and in subsequent laceration or rupture of the orbital capillaries, is another cause to be considered. A more direct factor to be thought of is those injuries, such as gunshot wounds and stabs about the orbit, resulting in subsequent effusion of blood from the vessels injured in the course of the wound.

A case in point (dealing with one of these very rare forms of spontaneous intraorbital hemorrhage) recently came under the author's care. The effect upon vision is seen in the fields of vision and the greatly diminished central sight.

C. Pissarello (*Archivio di Ottal.*, Vol. 22, p. 129) gives the history of a man, æt. 47, who while working in the fields, had a severe headache which lasted two hours. The next morning his left eye was much more prominent than the right. The exophthalmos increased for three days, at the end of which time the patient came to the clinic. The left eye appeared to be almost completely luxated outside the orbit, and was also 1.5 cm. lower than the right, although both orbits were symmetrically placed. The eye was immobile. There was marked general arterio-sclerosis, with blood pressure of 160-165 mm. Hg. The case was diagnosed as one of spontaneous subperiosteal hematoma of the vault of the orbit, and aspiration with a syringe brought away about 8 ccm. of a bloody fluid. The exophthalmos diminished, but after a short time returned to its former condition; and as the cornea was ulcerated, the patient was anesthetized and an incision made below the supraciliary arch. A large amount of blood was evacuated from a space between the bone and periosteum of the roof of the orbit. The eye was kept closed for three weeks by suture of the lids, and the patient made an excellent recovery, with vision of 20/40.

Orbit, Hydatids of the. See p. 6073, Vol. VIII, as well as p. 4123, Vol. VI of this *Encyclopedia.*

Cirincione (review in *Ophthalmoscope,* June, 1916, of *La Clinica Oculistica,* Dec., 1915) reports two of these rare cases. He points out that the diagnosis is established by:—

Exophthalmos. This has no pathognomonic importance but in cases of the present kind is always outwards and usually downwards rather than upwards. It is, moreover, associated with early loss of mobility of the globe. The cyst frequently develops in the belly of one of the muscles, and other muscles in close relation to the cyst often undergo

fatty degeneration. The rapid development of the proptosis is probably the reason of the failure of the lids to cover the cornea.

Exploratory puncture. It is rarely possible to find fluctuation in these patients; the depth of the cyst and its tension account for this. It has been held by some surgeons that the dangers of puncture are so great as to forbid its use. Cirincione thinks they have been grossly exaggerated in so far as orbital cysts are concerned, and lays stress on the importance of the puncture as a help to diagnosis.

Radiography. The shadow of such a cyst is greater than that thrown by neoplasms of the orbit except those which are bony.

The examination of the blood. This should be undertaken in two directions: (a) by the hemolytic reaction of Bordet and Gengou, which is allied to the Wassermann reaction; and (b) by the measure of eosinophilia. The first of these methods gives positive results in 93 per cent. of cases of echinococcus. The second has been shown to be a valuable form of evidence. The increase of the eosinophile cells is very marked, and disappears rapidly after the removal of the cyst.

Orbit, Hyperostosis of. See p. 6109, Vol. VIII of this *Encyclopedia.*

Orbit, Injuries of the. As this important heading is insufficiently treated under **Injuries of the eye** (See p. 6348 *et seq*, Vol. VIII of this *Encyclopedia)*, it is proposed to go more thoroughly into the subject here. It is also advised to consult the caption **Military surgery of the eye**, also **War, Ophthalmic medicine and surgery in.**

WOUNDS.

The orbital symptoms of injury to the skull are of special importance to the general surgeon, who is commonly the first consulted in such cases. Traumatic diseases of the orbit occur in 5 per cent. of all diseases thereof, but as they represent 0.19 per cent. of all ophthalmic diseases, the average ophthalmologist sees little of these rare injuries.

SUPERFICIAL WOUNDS OF THE SOFT PARTS AND OF THE RIM OF THE ORBIT.

Incised wounds of the soft parts of the orbital rim and of the face are very common, and especially so are lacerated and contused wounds occasioned by blows from blunt objects or from falls. In wounds of the superior and temporal parts the lachrymal gland may be involved. Extensive injuries to the orbit cannot be sustained without affecting the eyeball, as will be shown in a number of instances following.

Stab wounds are commonly seen extending from the forehead to the upper rim of the orbit, their direction being in the axis of the blow, from above downwards and outwards or inwards, as a rule producing wounds of the superficial tissues but in some cases penetrating the

bone to the brain. They may be perpendicular to the plane of the surface or tangential, in the latter causing flap formation, whereby a piece of bone may be cut and hang to the flap, especially in the case of incised wounds, as those from sabres. Blunter instruments cause fracture of the outer part of the bone which, too, may hang to the flap.

The *diagnosis* depends upon the depth of the wound and whether or not it enters the cranium. Inspection, palpation by sterilized fingers, and probing differentiates these from the deeper forms.

The *prognosis* as regards healing is usually good. If the wound be clean primary union may be effected; if infected healing ensues with more or less scar-tissue formation; phlegmonous inflammation or erysipelas may follow. Frequently part of the wound heals kindly, but in other parts small localized abscesses develop. The supra-orbital artery bleeds freely but is readily compressed, so that upon suturing the wound the hemorrhage ceases. Anesthesia of the side of the face occurs when the supra-orbital nerve is divided. In contusions or lacerated wounds the nerve twigs may be encompassed in the scar and give rise to neuralgia and even functional amaurosis.

The treatment is antiseptic surgery. In large wounds a drain may be laid within, besides suturing, and the drain removed in 24 hours, when the wound usually heals by first intention. If a piece has been completely excised from the lids, Thiersch grafts may be applied. The wound should always be carefully probed to determine its extent and the possibility of a foreign body lying therein, and the X-ray diagnosis should be made where possible. If the supra-orbital fascia be opened catgut drains may be put in, otherwise the wound should be fully sutured.

DEEP WOUNDS OF THE ORBIT.

Incised wounds of the orbital margin may be continued into the depths of the orbit, but these, as well as stab wounds, are uncommon except in war or personal assault cases. Punctured wounds from accidental injuries occur more often, the most common objects inflicting them being knives, hooks, pen holders, lead and slate pencils, ends of umbrellas, walking sticks, pointed pieces of wood, thorns, hoofs, pipe stems, files, cow horns, glass splinters, iron nails, ends of cold and glowing wire, sabres, bayonets, foils, lances, etc., may all enter the orbit and cause more or less incised, lacerated or contused wounds.

As a rule the object enters the orbit at the region of the inner canthus, from before, and passing into the depths of the orbit in many cases injures the optic nerve. Fortunately for vision the eyeball is usually pushed to one side and the wound often lies entirely in the soft

tissues between the globe and the orbital walls, and if the object does not injure the globe or nerve the injury may be altogether confined to a wound of the soft parts. Bleeding from a stab wound of this locality is slight, as the globe and the swelling of the tissues holds it in check from pressure.

The course of simple, clean, uncomplicated wounds is primary and speedy union. The exophthalmus rapidly disappears. In infection orbital phlegmon, erysipelas, meningitis and tetanus occur. If the periosteum be injured periostitis, caries and necrosis, emphysema of the orbit and lids. occurs.

Abscess and Cellulitis of the Orbit from a Blow by the Boot-heel.

The complications are many and severe. Fractures of the orbital walls with opening of the cranial or sinus cavities happen, by which the vessels of the brain may be injured and subsequent intracranial hemorrhage occur, or the nerves may be cut, with resultant paralysis. Injury to the globe, especially common being rupture of the sclera; more seldom luxation and avulsion; injuries of the optic nerve; the extra-ocular muscles; the lachrymal gland; tear sac and canaliculi. In quite a number of cases prolapse of the tear gland has been observed. Atrophy of the globe follows severe injury to the eyeball, especially in rupture of the globe and injury to the optic nerve. Ptosis, symblepharon, sinking in of the caruncle and dislocation of the tear passages are among the lightest of the complications.

Abscess and cellulitis of the orbit may arise from infected deep wounds.

The anamnesis and the examination showing a perforating lid wound, with swelling and bleeding into the tissues, especially if accompanied by a protrusion of the orbital fat, are pathognomonic. The swelling and bleeding of the lid wound is less where a foreign body is retained than in an open wound, as the passage is tamponed thereby. The change in position and loss of the motility of the globe speaks for injury either to the muscles or the nerve, and is characteristic of a deeply-penetrating wound. This may be passive from swelling, hemorrhage, inflammation, or retention of a foreign body. If the eye be blinded and no direct injury of the globe appear the opticus must have been injured, thus showing that the foreign body has penetrated deeply. The sterilized finger and the probe should be carefully used, likewise the X-ray; the former to determine the extent of the wound and to detect the presence of a retained foreign body, and the latter to localize it. In using the finger and the probe the globe should be pushed in various directions or pulled about by forceps in order that the examination may be thorough.

In favorable cases healing takes place in two to three weeks if complications, especially infective and inflammatory processes, have not occurred.

The treatment is antisepsis and coaptation of the parts.

FOREIGN BODIES.

The ends of objects entering the orbit may be broken off and retained. These injuries more often occur from accidents than from malicious assaults. In the trades, flying chips of metal or stone may go with sufficient force to penetrate the lids and pass into the orbit, or to pass completely through the eye into the depths of the eye socket.

Berlin, more than a score of years ago, stated that 6 per cent. of all ocular injuries occur in trades, but the proportion is now much higher, owing to the increase in the iron and steel industries; 45 per cent. now being due to outside accidents and 49 per cent. through injury by another person.

Perhaps dynamite and powder explosions give rise to the larger part of such cases, carrying chips of stone into the orbit; next come shot pellets, pistol balls and shrapnel.

Foreign bodies may pass through the conjunctiva into the depths of the orbit, commonly injuring the caruncle, or through the lids. Seventy-five per cent. pass by way of the inner canthus and glide easily along the nasal side of the orbital walls to the depths of the orbit, on account of most flying objects coming from downwards and out-

wards. Seldom does a foreign body remain superficial, and they seldom enter from the outer side.

The mode of entrance of foreign bodies into the orbit is usually through the anterior aspect, because of the protection afforded by the bones to the side walls. The inner angle is more often injured than the outer; more rarely the space between the globe and the roof, and very rarely the space between the ball and the floor, as the two latter are very narrow. Occasionally it reaches the orbit through the globe.

The patient is frequently unconscious at first from the force of the injury causing concussion of the brain, or great shock without producing an actual lesion of the brain. Afterwards he complains of pain, pressure, and headaches, generally of double vision if the muscles or the nerves be injured, and if the opticus be hurt there will be immediate loss of vision. The lid or conjunctival wound will be seen and the eye is usually to one side and more or less prominent from the orbital hemorrhage and effusion. Foreign bodies that lodge in the orbit usually cause no ocular symptoms, providing, however, the eyeball itself be not injured.

The loss of vision may be due directly to the injury by the foreign body when it damages the globe or nerve, or to compression of the bulb by the object itself. In other cases it is due to extravasation of blood into the tissues or to subsequent inflammatory reaction.

The optic nerve is edematous; the circulation obstructed; the veins tortuous and the arteries constricted, even to carrying no blood, and even when the nerve itself is not injured; and then, in many cases, after removal of the foreign body from the orbit the sight returns as the pressure upon the globe and the nerve is released.

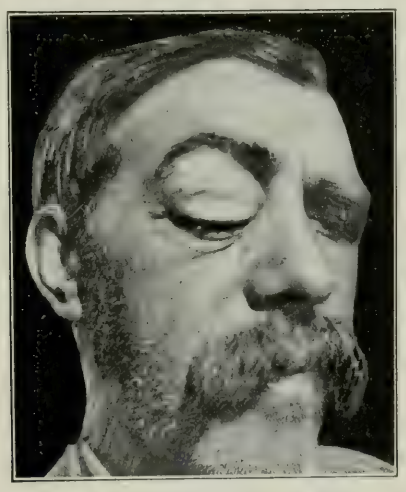
If the foreign body be very large or enters with great force it is liable to bore through the orbital walls, producing fracture and passing through the bone to the brain or nasal cavity; in one instance a splinter of wood passed even into the naso-pharynx. If into the brain, cerebral symptoms shortly occur. There have been cases in which even after such a severe injury the foreign body has been encapsulated and remained for months or years without causing severe inflammation.

Sharp-pointed objects of small caliber may pass through the optic canal or superior orbital fissure into the brain without breaking the walls, injuring thereby the optic and other nerves as well as the brain tissue. Even so can slender objects pass through the inferior orbital fissure to the temporal region, lacerating the inferior maxillary vessels or causing swelling and abscess of the aural region.

Aseptic foreign bodies may enter the orbit, cause but little reaction, becoming encapsulated and remain for years; especially, to be noted

is the occurrence in this location of shot pellets and pistol balls. Septic bodies cause intense reaction and may be found in the sinus leading to the abscess of the orbit caused thereby. This is particularly the case in injuries by twigs or splinters of wood, portions of which may come out from time to time in the discharge from the wound.

As a rule a suppurative process ensues, causing orbital phlegmon, from which the foreign body may be spontaneously extruded by way of the suppurating sinus. A fistula develops which may remain for years, and from which a sanguineous purulent discharge comes out. Inflammation of the periosteum and of the optic nerve is seen in the form of periostitis, caries, necrosis and optic neuritis.



E. Jackson's Case of Dislocation of Lachrymal Gland, and Foreign Bodies in Orbit. Condition on examination.

Complications are such as belong to surgical wounds with retention of a foreign body. Of special note is the occurrence of tetanus, quite a few cases having been noted in the literature. The treatment of cephalic tetanus is the injection of antitetanic serum, by means of which light cases may be led to recovery.

The diagnosis is plain if the foreign body be seen in the wound (which may be enlarged for the purpose of examination), touched by a probe or seen in a Roentgen-ray plate, which procedures should always be made when the first methods do not give the diagnosis.

The extent of the exophthalmus does not give any idea of the size of the intruder, for the protrusion is due to hemorrhage or effusion

rather than to the foreign body. Long and thin objects, as knife ends, slate pencils, pipe stems, umbrella ends, etc., may be difficult to find in the orbit if applied closely to the walls.

The diagnosis may be difficult if the object be aseptic, as a foreign body of considerable size may gain entrance to the orbit, causing loss of vision and motion, leaving but little evidence of the wound of entrance. In a few cases the patient has not been aware of the intruder, there having been but little discomfort after the first effect of the blow.

If a foreign body be aseptic and causes no inconvenience for some weeks, there is no reason why it should not remain for an indefinite period.

One of the first reported was the famous hat-peg injury of Brundenel Carter which had remained in the orbit 10 to 20 days without the patient being aware of it. The classic case of Noyes in which a breech-pin had not only gone into the orbit and cranial cavity but had healed therein and was not removed for five months, is most interesting; also that of Wright (see cuts on p. 6350, Vol. VIII of this *Encyclopedia*) in which not only the breech-block, but a long screw, remained for seven years before removal.

The history is apt to be misleading, as many of these cases are rendered unconscious and some of them are drunk at the time of the accident. Examination, if possible, of the object producing the injury will give some hint of its nature and perhaps of its size, if due to breaking off of the tip, as in the case of umbrellas, sticks, etc. The breech-block injuries from bursting firearms are of much interest in this connection. In many of them the retention of such a large foreign body was at first unsuspected.

In a case of injury to the eye or face through gun explosions one should think of the possibility of missiles having been blown in out of sight, not only the breech-pin, but also the stock-bolt or stock screw. Also that, whether or not the presence of a foreign body can be detected by probing, it is well worth while to have one or more skiagraphs taken.

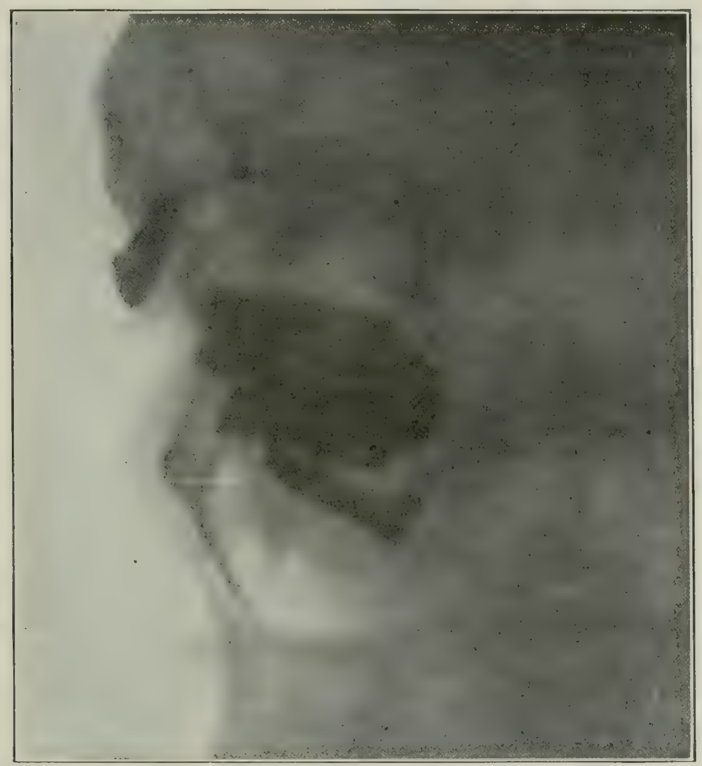
In a number of cases of shot gun injuries whereby the globe had to be enucleated the writer has found one or more shot in the orbit.

Then, too, the possibility of a small foreign body having passed entirely through the eyeball into the orbit should be carefully considered in penetrating wounds of the eyeball from shot pellets, and particularly in trade injuries.

The prognosis can only be good when the foreign body has not caused great direct damage on entering; when it may be easily removed without too great disturbance of the structures; and when the

resultant wound will not be followed by inflammatory and cicatricial changes.

As noted, some exceptional cases have been reported where a foreign body has remained for years without giving rise to severe symptoms and has been removed or was spontaneously extruded. To account for such instances it must be supposed that the orbital tissue is particularly



Skiagram of a Breech-pin in the Orbit. (Gifford.)

immune to infection, or else the foreign bodies that have gained entrance into the orbit have been aseptic.

The future usually depends upon the extent of the injury and its resultant complications. If the optic nerve be not directly injured the vision may become better, even normal, upon removal of the foreign body. Even here we must be careful in our prognostications, for secondary inflammation may occur in the orbit, resulting in atrophy of the nerve or even of the globe. If both nerves be injured the patient

usually dies from concomitant brain injury, but some live to pass their days in blindness.

Small metallic objects, as shot pellets, bullets, chips of iron, copper, stone, etc., may be left alone to become encapsulated. However, bullets have been successfully removed from the orbit with conservation of the globe. The length of time that objects of other characters remain in the orbit not only brings the danger of orbital phlegmon, but also of inflammation of the optic nerve and resultant blindness; so that operation for their removal should be instituted before severe inflammation with great swelling renders it more difficult and dangerous. In fresh cases, after localization by the X-ray, the opening should be carefully probed and enlarged in the direction of entrance; in older cases the sinus followed up or the cicatrix cut open, the foreign body seized by forceps, cut away from the tough connective tissue by scissors, carefully dissected out and withdrawn in the direction of least resistance, or where the procedure will do the least damage.

INJURIES FROM BLUNT OBJECTS.

Exophthalmus from orbital hemorrhage. As a rule the bleeding occurs from direct or indirect injury to the walls of the orbit, the former by shot and stab wounds where the vessels are directly opened; the latter in fractures of the walls where the blood comes from the periosteal lining of the orbit, the facial sinuses, the base of the brain and the vessels of the latter.

When the injury is a contusion the bleeding fills up the orbital cellular tissue, causing moderate exophthalmus, but when the tissues are badly torn, as from fracture of the walls and laceration of the contents, the proptosis may be very great. Therefore it is reasonably safe to suppose a fracture when the exophthalmus is severe. In many cases only the autopsy determines the actual amount and cause of the lesion.

A small amount of hemorrhage does not give rise to any symptoms unless the blood extravasates under the conjunctiva and lids, when it appears as an ecchymosis. However, such a suggulation may appear as a blood tumor or hematoma of the conjunctiva and in the case of much bleeding behind the eye to cause a hematoma of the orbit with resultant exophthalmus, hindrance of the ocular rotations, double vision from strabismus and loss of sight from pressure on the optic nerve. The eye does not protrude directly forwards, but usually outwards and down or upwards, depending upon the pressure exerted by the blood clot. The greater the protrusion the less the amount of ocular movement, as the muscles are stretched, pressed upon and have

no room for contraction. The recti nerves are also subject to pressure, and this may lead to degenerative atrophy.

Bleeding under the conjunctiva and into the lids may not be apparent at first, but generally shows after several days. When it happens immediately it is a sign of contusion of these structures. On pressure the eye does not recede into the orbit and it also seems firmly fixed above, below, and to the sides. The patient complains of a feeling of pressure and fullness and has considerable pain, but not as in the case of orbital phlegmon. The sight fails from pressure on the nerve, bleeding into the sheaths and from direct injury. The prominence of the globe straightens out and stretches the optic nerve, but does not cause the loss of sight. The fundus examination is negative unless the nerve be compressed, when the fundus is edematous and the arteries carry little blood, the veins being tortuous. When the nerve is injured directly the circulation is thereby cut off.

The resorption occurs in three to four weeks. The vision and motility usually return if the nerve be not directly injured by laceration or bleeding into the sheath.

In old and weak individuals the resorption is much slower. The hematoma may develop into an orbital abscess if infected by a foreign body, via a wound of the skin or from a nearby sinus, especially the nasal, frontal or ethmoidal or sphenoidal, and bacteria thereby find lodgment.

The protrusion of the globe leads to lagophthalmus and corneal ulcertion.

The diagnosis is secure upon finding increased pressure of the orbital contents, protrusion of the globe, and suffusion of the lids after a trauma.

If abscess supervenes fever develops and the pain is very great, the local temperature rises and palpation shows fluid. Concurrent fracture of the walls is difficult and often impossible to diagnose.

The prognosis of orbital hematoma without fracture of the walls is good, as most cases result in full recovery after about one month.

The treatment is a pressure bandage and the ice bag. As a rule it is not advisable to make incisions to withdraw blood unless the high grade of protrusion gives reason to fear for the safety of the cornea.

Contusions of the soft parts of the orbit. Bleeding into the tissues of the orbit with contusion is very common from blows and falls, forming a part of the picture of the ordinary black eye discussed more fully heretoforé. The bleeding may occur in the form of a tumor under the skin, the fascia or the periosteum, and it spreads very rapidly through the tissues, appearing in both lids and proceeding under the

skin of the root of the nose to the other eye. In many cases the edema is so great that the lids cannot be separated at will.

The course is favorable, as the resorption is usually complete in a couple of weeks. In scrofulous children and syphilitics blows and falls upon the orbital rim may first cause contusions, but later lead to periostitis and caries. In severe cases the question of fracture should be determined.

The treatment is a compress bandage, iced compresses, and massage. After several days hot compresses aid in resorption of the blood and blood stain.

Contused and lacerated wounds of the soft parts of the orbital rim. Blows (and falls) from objects which compress the tissues between them and the orbital walls.

As a rule contusions of the orbital rim are accompanied by more or less solution of continuity of the skin and overlying tissues. Of particular interest in medico-legal practice is the sharply-defined wound of the upper and outer part of the brow, produced by falls or blows, as the medical witness will surely be asked if it is not possible that this was produced by a knife or other sharp instrument. This goes to the bone, but not into it, and the injury is greater next to the bone and it does not gape as would be the case of a cut by a knife. As a rule severe edema of the wound and eyelids follows, so that the eye cannot be opened.

Infection is quite probable, for the edges of the wound are contused. Periostitis, caries and necrosis are common sequelæ. Local and phlegmonous inflammation and gangrene of the soft parts may follow, with death from septicemia.

By greater force fractures accompany the injury and may be attended by emphysema from the air coming from the nasal cavity.

Such injuries may be attended by contusion and laceration of the deeper parts of the orbit, and in fact, when found, this contingency should never be overlooked.

Inoculation by syphilis has happened from a bite wound.

Tetanus has been reported by many observers.

Enophthalmus follows such injuries, especially if accompanied by fracture. Supra-orbital amaurosis is an interesting complication.

There is a contused wound, generally of the upper and outer orbital margin, lying lengthwise with the orbital rim, and the injury is greater nearer the bone than at the skin, while knife wounds gape open and are smaller in the deeper parts than at the skin edges.

The prognosis is generally good, although a scar remains which may sometimes be depressed and attached to the periosteum.

The treatment consists in freshening the edges of the wound and suturing. If infected, drainage and surgical dressings.

Cases of supra-orbital neuralgia due to callus and fracture about the supra-orbital foramen, have been reported.

Newolina reports an interesting case of pistol wound in a man, aged 44. There was instantaneous blindness without ophthalmoscopic changes, which gradually developed into atrophy of the optic nerve and narrowing of the blood vessels. From the symptoms and Roentgen photographs, the shot apparently entered the orbit between its inner wall and the eyeball to the superior orbital fissure, along the osseous septum between this and the optic foramen, the cavernous sinus, above the Gasserian ganglion to the upper face of the temporal pyramid, where it became lodged. It injured the optic nerve, most likely the upper portion, in its avascular part, the ophthalmic branch of the fifth nerve, grazed its ciliary twigs, and contused the oculomotor and trochlear nerves.

In a case of attempted suicide, under the care of Casey Wood (*Pr. Med. Series,* Eye, p. 159, 1909), the bullet passed through the orbit into the nose without direct injury to the optic nerve, yet the patient became totally blind, thus confirming the suspicion of many observers that molecular changes within the nerve tissues may take place without actual contact with the missile.

Supra-orbital amaurosis and amblyopia. The blinding or diminution of vision from a blow upon the forehead is either due to injury of the brain, the optic nerve or the bulb, and the so-called reflex amaurosis must be referred to these causes, even if in the living case we may be unable to definitely fix the lesion to any one locality.

Certainly most cases are due to fractures at the optic foramen, but there is described by certain authorities a form of reflex amaurosis after injury to the supra-orbital nerve, a sensory twig of the trigeminus, which is an analog to reflex amblyopia with contraction of the field of vision caused by disease of the teeth, the nerves in the intestinal tract, and to the sympathetic irritation of irido-cyclitis.

FRACTURES OF THE ORBIT.

Contusion and isolated fracture of the orbital margins. Contusions of the bony margins of the orbit, especially in children, through falls or blows, are very common. The soft parts are bruised and periostitis or caries may follow, especially in scrofulous subjects, with formation of pus and a fistulous opening. Emphysema of the lids and brows occurs from breaking of the frontal or ethmoidal sinus walls.

Detachment of portions of the bone may occur from bullet wounds.

Isolated fractures of the external or internal tables of the frontal, malar or upper jaw bones sometimes occur, but are rare.

The diagnosis is from the abnormal passive movement and coaptation and from X-ray examination. One should be sure that other bones of the face and orbital wall are not implicated.

Prognosis is generally good, but unsightly depressed cicatrices may follow and the soft parts may become adherent, producing ectropion.

The treatment is removal of fully detached portions of bone, or in their reposition by wiring, nailing and bandaging, together with surgical care of the wound of operation.

Fracture of the orbital walls and the facial bones. The conditions of displacement, the symptoms, as well as the complications of orbital and facial fractures differ according to the location and are better taken up separately.

Generally we differentiate: 1. Direct isolated fractures, with or without displacement of the fragments. 2. Fractures from radiation or extension of those of the skull or facial bones. 3. Isolated indirect fractures, or those from contrecoup in which there is an unbroken part between the place of impact of the force and that fractured.

Direct fractures are caused by shots and punctures, likewise fractures from extension, but, in addition, through blunt force, as falls, blows and thrusts; the isolated and indirect fractures from contrecoup.

Hemorrhage under the conjunctiva and into the lids and orbit, with exophthalmus and dislocation of the globe, is apparent from the hematoma. In a few cases the globe may be moved from place by dislocation of the bony fragments.

Opening of the cranial cavity and facial sinuses; injury to the orbital contents, especially the eyeball and the optic nerve, the blood vessels, muscles, nerves and lachrymal apparatus; and exophthalmus, are common complications.

The course may be complicated by inflammation of the opticus, causing a descending neuritis with resultant atrophy, adhesions in the orbit and loss of motion of the globe, and cicatricial contraction of the orbit so that a prothesis is impossible without plastic operation, and not then satisfactory. There is danger of infection of the wound either externally or from the sinuses, with orbital phlegmon, sinus thrombosis, meningitis and encephalitis.

In a few cases the break may be seen or felt by the finger or probe. The abnormal movability of the fragments shows the fracture. We may seldom observe crepitation which is so apparent at the rim of the orbit or in other bones. Bleeding under the conjunctiva, into the lids,

and the hematoma of the orbit, with full and rapid protrusion of the eye, and great pain on pressure near the broken region, are pathognomonic.

The fragments may be felt in the orbit upon light pressure by using the fingers. When the hematoma resorbs enophthalmus may result. Localization may be made by the concomitant symptoms. Where the cranial cavity is opened, brain symptoms occur; where the accessory sinuses are opened, emphysema; and in fracture of the apex, one-sided amaurosis may be seen if the optic nerve be injured.

Fractures of the orbit are always dangerous and their effects often impossible to prognosticate. When the cranial cavity is opened and there is infection, the prognosis as to life is bad. When the eye or optic nerve is injured, or is involved later by inflammation, the outlook as to sight is likewise very bad.

Aseptic surgery constitutes the line of treatment; foreign bodies and loose splinters of bone must be removed. If the accessory sinuses are involved the nose should be gently cleansed, but not douched, and packed with iodoform gauze strips, removed within 48 hours.

Fracture of the roof of the orbit. Of all fractures of the orbit, that of the roof is the most important and dangerous to life, as here the cranial cavity is impinged upon or entered, the meninges and brain tissue injured, with danger of resulting meningitis and abscess, followed by death.

The direct isolated fractures are usually from penetrating and firearm injuries, which come from the front or sides and upwards through the orbit, more seldom from the side or from the mouth or nose.

The radiation fractures may come from shot, usually those through the mouth, or from severe blunt force as blows or falls, and proceed from the vertex of the skull, usually the frontal bone, down to the roof of the orbit. The force may be exerted only on one side, but it may be upon both, or from the compression by the forceps in childbirth.

In suicidal shots into the mouth the bullet passes through the hard palate and the base of the skull, injuring the sphenoid and passing into the middle fossa of the skull from which the fracture extends to the orbit. Shots from an oblique direction seldom give rise to this form of fracture.

Isolated indirect fractures of the roof occur in connection with bullet fractures of the vertex.

The external appearances in direct fractures are those of a penetrating wound of the orbit. The inner angle is the usual point entered, then the upper lid, more seldom between the eyelids at the point of transmission.

About one-fourth of the cases of brain injury in this connection prove immediately fatal. In the others there is unconsciousness, delirium, headache, vertigo and weakness. The symptoms of concussion of the brain, as slow pulse and vomiting, are not constant. Convulsions, hemiplegia, etc., depend upon the part of the brain injured. The further course is inflammation and fever with meningitis. Most of the cases are later fatal from the direct injury to the brain, hemorrhage, meningitis or encephalitis. In a large proportion of the cases that live through the injury, secondary affections, as hemiplegia, headache and vertigo, epilepsy, insanity and imbecility, follow the injury.

In fractures by irradiation or contrecoup, of the roof of the orbit, there are symptoms of fracture of the base of the skull and concussion of the brain, especially bleeding from the ears, nose and mouth, as well as orbital hematoma, with quickly developing proptosis, conjunctival suffusion and suggulation of the eyelids; and, by injury to the optic canal, one-sided blindness, besides loss of consciousness, vomiting, superficial respiration, small pulse, disturbances of motion and speech and loss of function of the nerves passing along the base of the brain. But few cases of brain concussion occur without these symptoms, which are here proportionately greater than those of direct laceration of the brain tissue, occurring in direct fracture of the roof of the orbit and which cause pronounced localization symptoms.

If the effect of the force be exerted on the forehead, orbital margin, or in its neighborhood, a defect in the bone and displacement of the fragment may be observed. In mouth, temple and other skull shot wounds the connection may not be seen but be inferred from the resulting symptoms. While shot wound fractures of the orbital roof connected with injuries to the brain usually prove lethal, uncomplicated cases generally recover. At least a fatal ending is less common than when complicated or than in direct fracture.

Opening of the fissures of the orbital roof between the frontal, ethmoid and sphenoidal bones may be caused by a moderate degree of contusion, such as blows upon the rim of the orbit, blows or falls on the head, or on the feet or buttocks, without causing brain symptoms or exophthalmus, and the main symptom be a slight degree of subconjunctival hemorrhage.

In direct breaking of the orbital roof there is always opening into the anterior fossa of the skull, the bone being very thin in this location, and commonly there is laceration of the meninges and the substance of the brain and the entrance of the object producing the injury. The retention of a foreign body or the impaction of broken bits of bone into the brain is very unfavorale to life. A few authors have reported

caries and necrosis following an irradiating fracture of the roof of the orbit.

The anamnesis is of aid in determining the existence of a direct injury and where the brain is injured the symptoms of laceration will appear.

The rapidly occurring suggulation of the lids and conjunctiva, and hematoma of the orbit with exophthalmus, the prolapse of orbital fat and occasionally of brain tissue, show the character of the lesion. Where the brain symptoms fail the diagnosis is difficult, although they often ultimately occur as meningitis, encephalitis, with unconsciousness and other symptoms from intracranial hemorrhage. Therefore it behooves us to keep these patients quiet in bed for several weeks after such an injury.

The direct examination of this form of fracture is often impossible, as it is often in the depths of the orbit and the bulb covers the wound canal; as during the infliction of the injury the eyeball may have been pushed to one side and afterward returned to its place. The sterile finger here makes the best and safest sound and is not so apt to push broken fragments of bone farther into the brain. Unless there be evidence of a retained foreign body probing is superfluous and dangerous.

In radiating and isolated fractures by contre-coup the symptoms of basal fracture and brain concussion, with the rapidly occurring bleeding into the lids, under the conjunctiva and into the orbit, with proptosis and the generally occurring blindness, are prominent symptoms. Bleeding from the ear means fracture of the petrous bone. Bleeding from the nose may only be due to injury of the soft parts. Flow of cerebro-spinal fluid from the ear and nose, the latter from the cribriform plate of the ethmoid, means a basal fracture. Where the margin of the orbit is fractured the fissure may be seen as a notch, or felt by the fingers.

Direct fracture of the roof of the orbit is unfavorable to life and the few who live usually have severe secondary affections. In contradistinction the prognosis of basal fracture with radiation to the roof of the orbit is comparatively good, although commonly blindness results, as the fracture may extend to the optic foramen.

In direct fractures we should, under rigid aseptic precautions, freely open the wound of entrance and remove foreign bodies, bone splinters and wound secretion. Probing and irrigation are not to be done, as pathologic products may thereby be carried deeper into the tissues and cause infection. This is to be remembered likewise in dealing with orbital abscesses. Gauze drainage from the opening will remove the secretions with less danger.

The operation may be best conducted through an incision through the brow, the skin being well retracted, and if necessary resection of the margin of the orbit made in order to safely reach the foreign body for its removal and that of the broken bone splinters. The finger here makes the best probe, and by it the broken bone may be diagnosed and the splinters seized with forceps and removed.

When the posterior part of the roof is fractured and a foreign body known to be therein, as the eyeball has usually been destroyed, enucleation or partial exenteration of the orbit may be done, and thus direct access to the fracture be obtained, the foreign body and bone splinters brought into view and soon easily removed, and the wound secretion better drained. All splinters should be taken away, as even very small ones may later cause inflammation, meningitis, brain abscess and loss of life. If a localized brain abscess, which is common in bullet hole fractures, is found, it should be opened and drained.

In the milder cases, as where brain symptoms do not occur, the eyeball may be retained and simple drainage of the wound secured, but where the bulb is injured there should be no compunction about an enucleation, as we thereby secure a better diagnosis and drainage.

The treatment of irradiating and contre-coup fractures is that of fracture of the basis cranii. If foreign bodies occur and bone splinters are found they should be removed under stringent asepsis.

There have been many cases of direct fractures of the roof of the orbit observed from ancient days. The eye has ever been the mark for the arrow, for the bullet and for the fist.

Fracture of the outer wall. Fractures of the outer wall may be direct and these most often due to bullet wounds, less frequently to punctures and irradiating fractures proceeding from those of the orbital margin or the zygoma. In war time, and more in the olden days, injuries from bayonets, sabers, and knives were more common. The wall is usually injured from the temporal side rather than from the orbit. The foreign body passes, with or without injury to the globe, to the floor of the orbit and may also break this or pass through the lower fissure. The lachrymal gland is seldom involved, as it is well protected by the projection of the brow.

In firearm injuries the force generally comes from outwards and the orbital contents, as well as the globe, are generally greatly damaged. Of these the globe, the nerve, the orbital vessels, muscles and nerves are most affected, and the intra-orbital bleeding produces hematoma with marked exophthalmus. The occurrence of corneal necrosis arizes from injury to the ciliary ganglion and nerves, as well as to the posterior long ciliary arteries.

The diagnosis is from appearances and sounding by the finger and probe. Crepitation may commonly be elicited.

The prognosis depends upon the amount of injury and damage to the eyeball.

The therapy is surgical.

Fracture of the inner wall of the orbit. Direct fractures come from punctures and shot wounds. In bullet fractures the inner walls of both orbits are usually broken on account of their contiguity and thinness. Nearly all these fractures come from bullet wounds.

Reber's Case of Emphysema of the Lids Following Fracture of the Inner Wall of the Orbit.

Irradiating fracture occurs with fracture of the base of the skull, usually connected with that of the roof of the orbit, then the frontal, malar, the upper jaw bones, connecting with the thin lamina papyracea of the ethmoids and the lachrymal bones. These fractures come from blows, falls and shot wounds.

The break is generally due to direct force and is evident to the examining finger. Two characteristic symptoms occur, bleeding from the nose and emphysema of the orbit and lids.

The prognosis is good, barring complications of infection and orbital abscess, which arise from external wounds or from those of the sinuses.

The treatment is surgical and especially prevention of infection by tamponade of the nose by iodoform gauze. Injections are not to be made on account of carrying infection to deeper structures.

Fracture of the floor of the orbit. Direct fractures result from all forms of foreign bodies and implicate the maxillary antrum, nose and

naso-pharynx, or may first pass through these cavities to the orbit. These may either be from punctured or shot wounds. Bullet wounds from the temporal side may shatter the floors of both orbits; those from the mouth may range upwards and pierce the floor of the orbit, injuring the globe and passing up into the brain.

When inflicted by great force radiating fractures extend from the maxilla, malar and base of the skull. The causes of these are usually blows or falls upon the face. Such a fracture may be primarily in the orbital wall and extend to the malar, or conversely from the zygoma to the base of the skull. The break is often evident by a depression or can be felt by the finger. Bleeding from the nose and emphysema

Fracture of the Nasal Bones, Nasal Process of Frontal, Ethmoids and Roof of the Orbit, with Paralytic Ptosis and Saddle-nose.

from opening of the maxillary antrum are common. Infraction of the lower margin of the orbit and dislocation of the globe are seen.

The healing and course are favorable if uncomplicated. Commonly the injury to the infra-orbital nerve leaves loss of sensation of the cheek.

The therapy is symptomatic. The fragments may be raised and held in position by wiring or nailing.

Fracture of the malar bone. As a rule malar bone fractures are combined with those of the upper jaw or zygomatic process of the temporal bone. They are generally direct injuries, though, as noted under fractures of the floor of the orbit, may be due to irradiation from the base of the skull or orbital rim.

The malar bone may be torn away from its sutures with the maxilla and luxation be thereby constituted. As a rule these injuries are due to crushing of the head or to heavy blows, as from a horse's hoof. The cheek is depressed, the dislocation of the broken fragment being backwards and downwards. If the break go through the floor of the orbit the infra-orbital nerve is injured, with loss of sensation of the cheek. The usual symptoms are crepitation, exophthalmus, bleeding into the orbit, conjunctiva and lids, from the nose and mouth, difficulty and pain on chewing on account of partial laceration of the masseter, or movement of the fragments of bone against the coronoid process.

The diagnosis is based upon the general symptoms of fracture, the flattening of the face, pain on chewing and direct examination by the finger.

The prognosis is good, most cases making recovery.

The therapy is symptomatic. The bone should be replaced by manipulation and held in position by bandaging.

Fracture of the superior maxilla. Fractures of the upper jaw occur from the same causes as those of the malar bone. In but few cases is this bone injured separately. Generally it is combined with fracture of the malar, ethmoid, nasal, lachrymal, nasal processes of the frontal, walls of the orbit, base of the skull and lower jaw from severe compression of the head, kicks from horses or heavy blows from blunt objects. Railway wrecks, elevator and runaway accidents are usual causes. Fracture likewise occurs from bullet wounds. Dislocation of fragments may occur into the orbit and cause injury to the globe or nerve, orbital hematoma, exophthalmus and emphysema. Bleeding from rupture of the superior maxilla is dangerous.

The diagnosis is from the loosening of the jaw and symptoms generally of fracture. The prognosis is good when there is no fracture of the base of the skull. The treatment belongs to the general surgeon, who replaces the fragments and wires them into position.

The general surgical treatment of fracture of the orbital walls consists in reposition, removal of loose fragments, and rest.

In splintering and comminution of the bones, with external wounds in complicated fractures, the loose fragments should be removed by forceps, attended by dissection of retaining bands of tissue by blunt-pointed scissors. However, loose fragments that yet remain attached by a good sized band of periosteum, which can be replaced and held in position, may be reposited and will heal in place. Fragments that have pierced the soft tissues may be elevated, cleared from the tissues, and properly replaced, being held by periosteal catgut sutures, metal

clamps, or even by sutures placed in the soft tissues and supported by a retention bandage.

Simple fractures, without solution of continuity of the external skin or mucous lining of the walls of the sinuses or the dura mater of the cerebral cavity, are generally amenable. The complicated fractures which open up the sinuses need no direct form of surgical interference. They are generally upwards and inwards, or inwards and downwards, and lead to infective processes from tearing of the mucous membrane lining the sinus. Fractures of the inner-upper walls cannot be replaced except by external incision, which may be made below the eyebrow and the bone reposited by periosteal probes and forceps.

Those of the inner wall and those of the nasal processes may be replaced by manipulation through the nasal passages by the flat nasal probe, and held in place by nasal tampons. The treatment is usually combined with that of fracture of the nasal bones and heals with an external splint made out of dental rubber or composition to mould the external nose into shape. If the accessory sinus be involved the nose should be gently cleansed, but not douched, and packed with iodoform gauze strips, which should be removed within 48 hours.

Fracture of the zygoma may extend into, and a piece penetrate, the maxillary antrum. This may be replaced by the forefinger of one hand of the operator entering the mouth well behind the zygoma and the piece raised by the finger into place, the head being steadied by the operator's other hand. If this is not possible a strong resection hook is passed around the zygoma at the nasal process and it is pushed into place. If the fracture be complicated by an open wound then the splintered bone may be reached through the opening and raised by forceps or penetrated by a screw and thereby purchase given to relieve the impaction and replace the fragment.

In old healed fractures of the orbital rim, as well as in uncomplicated fractures, an external incision may be made with resection of the bone—i. e., an osteotomy—in order to reach the injured part, free the impaction and replace it.

Direct fractures of the orbital rim are the rule. Indirect fractures without replacement of the fragments require no operative interference. They are accompanied by indirect fracture of the orbital wall and usually with fracture of the base of the skull.

Direct fractures of the orbital walls are, as a rule, due to penetrating injuries of the orbit, are isolated, and are more amenable to surgical intervention than the indirect.

Under rigid antiseptic precautions one should freely open the wound of entrance, remove foreign bodies, bone splinters and secretion. Prob-

ing and irrigation are not to be done, as pathologic products may thereby be carried deeper into the tissues and cause infection. This is to be remembered likewise in dealing with orbital abscesses. Drainage with gauze will remove the secretions with less danger. The operation for fracture of the roof of the orbit may best be conducted by an incision through the brow, the skin well retracted, and, if necessary, resection of the margin of the orbit made in order to safely reach the foreign body for its removal and that of the broken bone splinters. The finger here makes the best probe, and by it the broken bone may be best diagnosed, the splinters seized and removed by forceps.

When the roof of the orbit is known to be fractured and the foreign body be therein, as the eyeball has usually been destroyed, enucleation of the globe or a partial exenteration of the orbit may be made and thus direct access to the fracture be obtained, the foreign body and bone splinters brought into view and more easily removed, and the wound secretion better drained. All splinters should be taken away, as even very small ones may cause inflammation, meningitis, brain abscess, and loss of life. If a localized brain abscess (which is common in bullet fractures) is found it should be opened and drained.

In the lighter cases, as where brain symptoms do not occur, the eyeball may be retained and simple drainage of the wound secured, but when the bulb is injured there should be no compunction about an enucleation, as we thereby secure proper diagnosis and drainage.

In complicated or old healed fractures of this character, as the deformity is the only defect, it may be well to leave the matter alone, as no evil results have been reported from such conditions.

The treatment of irradiating and contre-coup fractures is that of *fractura basis cranii.*

INJURIES TO THE ORBIT, FROM FIRE-ARMS.

Injuries to the orbital margins. Glancing or superficial wounds of the orbital margins may occur when the shot does not come from in front, but from the outer, upper or a downward direction. It may carry away a piece of the soft tissues or bone and produce contusion of the globe. Seldom does the shot remain in the orbital margin.

Injuries to the walls of the orbit and contents. Injuries to the roof. If the bullet comes from above and in front it splinters the upper margin and roof, ranging downwards, destroying the eyeball, passing through the anterior portion of the orbit, through the floor and outer wall, the face, and out of the head, usually by the aural region or through the naso-pharynx and neck.

Shots ranging from below upwards through the roof to the brain

have more interest for the coroner than the ophthalmic surgeon, as they are invariably, and generally immediately, fatal.

Injuries to the floor. As noted above, shots ranging from above pass downwards to the neck through the floor of the orbit. Grazing shots affecting superficially or passing through and fracturing the jaws and malar bone likewise shatter the walls of the orbit, particularly the floor. Those ranging from below pass upwards through the neck, face, floor and roof of the orbit into the brain, or the bullet may be stopped where resistance is sufficient and thus lodge in the root of the nose, orbital rim, base of sphenoid or its cavity, and surface of the frontal bone.

Temporal wall injuries. The temple being the favorite situation for the would-be suicide to press his revolver muzzle, and at least 50 per cent. of them pointing the barrel too far forward and thus failing in their immediate attempt, a large number of injuries to the eyes and orbit have been reported from this cause. Likewise in modern long range war, the shot injuries to the head have increased in proportion to those of the body.

The bullet passes from the temporal region through the outer wall of the orbit, destroying the eyeball if striking it; if passing behind, cutting through the optic nerve or avulsing the globe. The bulb and nerve may escape injury, but this, as well as the bullet remaining in the orbit or nasal cavity, is rare. Such injuries in war are usually fatal.

Inner wall injuries. The bullet may pass through the base of the nose or from the nose into the orbit; glancing and tangential shots passing through the superficial part of the face may range upwards and inwards to the inner wall, those passing through the inner wall of the side of the orbit anteriorly may range backwards and across the medial line and perforate the inner wall of the opposite orbit and destroy the optic nerve or globe.

Bullet injuries from behind. The bullet may range from the occiput forwards, reaching the eye and orbit. Also the bullet may enter the skull near the ear and pass forwards to the orbit, commonly destroying or tearing out the eye in its passage. Such injuries are only of medico-legal and mortuary interest.

Shot injuries of the orbital contents without injury to the walls. The amount of damage done to the eyeball and orbital contents depends upon the size and velocity of the projectile, as well as the parts upon which the injury is inflicted.

In such bullet wounds of the orbital contents the eyeball is usually torn open; in shot wounds penetration or perforation of the globe is common, but at the same time shot pellets may be impacted in the

tissues with or without injury to the globe. Cases have been known of penetration of the orbit by a bullet in which no physiologic damage resulted.

WAR INJURIES OF THE ORBIT.

Of course these far outnumber and overshadow all civilian experiences. The reader, therefore, is referred to p. 7706, Vol. X of this *Encyclopedia* under the heading **Military surgery of the eye,** and also to **War, Ophthalmic medicine and surgery in.**

Of the many *protheses used in the reconstruction of the blinded soldier*, Sir William Collins (*Lancet*, June 17, 1916) incidentally describes one. He relates the case of a private who was severely wounded on the right side of the face. The wound extended from the ear to the nose, the soft parts including the right globe and portions of the eyelids being destroyed. There were fractures of the right malar, superior maxillary, lachrymal, and nasal bones, causing a large opening between the nose and the right orbit. Seven operations were performed by the French surgeons Bettremieux and Ballenghien, who, as well as the patient, were prisoners in Germany. Two further plastic operations were performed by Collins when the patient reached England; but eventually, and this is obviously the most interesting point, Collins designed an artificial cheek of painted and moulded copper plate, with eye attached, set in a pair of spectacles. This was made by Mr. Eastgate, of Messrs. Sillis, Strudwick, and Co. Four photographic pictures of the patient show various transformations in his appearance from the early days of the injury in October, 1914, to his dismissal from hospital wearing the appliance. These photographs form a most striking commentary on the skill with which this patient has been treated.—(H. V. W.)

Orbit, Lipoma of. See p. 7496, Vol. X of this *Encyclopedia*.

Orbit, Lymphangioma of. See p. 7559, Vol. X of this *Encyclopedia*.

George Mackay (*Ophthal. Review*, p. 177, 1915) described a case of lymphangioma of the orbit with hemorrhages, seen first in 1906, in a child who was then 15 months old. Paracentesis, and, later, excision so far as practicable having failed to eradicate the growth from the apex of the orbit, X-ray treatment had been employed, and with much benefit. Owing to the irregularity in the patient's attendances proptosis had been allowed to recur, at intervals of one to three years, but had always yielded to further X-ray applications. The cure now appeared to be complete, and vision and movements were unimpaired.

Orbit, Lymphoma of. See p. 7563, Vol. X of this *Encyclopedia*.

Orbit, Myasis of the. FLY-BLOWN ORBIT. Azer Wahba (*Bulletin of the*

Egyptian Oph. Soc., p. 84, 1915) has reported four cases of this condition, three of them in children of 18 months to 3 years. The appearance resembled somewhat panophthalmitis, except that the lids were more extensively involved and large holes were found in the tissue. There was free discharge of pus in all cases, and in the children this contained gonococci, suggesting that a gonococcal conjunctivitis had preceded the invasion of the tissues by the larvæ. The number of worms present varied from three to fifteen, and one of the holes left, from which three had been extracted, was large enough to admit the end of a little finger. In the discussion of this paper, four other cases occurring in children were reported, and in two of these cases the gonococcus had been found. See, also, **Parasites, Ocular,** in this *Encyclopedia.*

Orbit, Necrosis of the walls of the. See **Orbit, Abscess of the**; also see p. 1426, Vol. II of this *Encyclopedia.*

Orbit, Neurofibroma of the. As stated elsewhere mixed neuromata of the orbit are commoner than the neuroma proper.

In a case described by Parker (*Journ. Am. Med. Assocn.*, July 6, 1907), exophthalmus downward and outward, with limitation of motility, double vision, good sight and normal fundus were the chief symptoms observed. A tough tumor was felt deep in the orbit appearing to surround the globe, to which it was not attached. A curved incision was made over the temple, extending along the outer margin of the orbit dividing the periosteum and running backward along the upper edge of the zygoma. Periorbital and orbital contents were resected and the lateral wall cut through with a chisel, above, in the suture between the great wing of the sphenoid and the malar bone, and below in a horizontal plane directly above the insertion of the zygomatic arch. This piece of bone with its soft tissues attached was forced backward, giving free access to the orbit. The periosteum was then divided horizontally, and the tumor extirpated without difficulty. It proved to be a kidney-shaped mass, imbedded in which were the frontal, supra-orbital and supra-trochlear nerves. It had evidently originated in the sheath of the frontal.

M. E. Valude (Review in the *Oph. Review*, June, 1910, of *Annales d'Oculistique*, June, 1909) describes a case of neuro-fibroma of the orbit which occurred in a woman aged 34. Twelve years previously she noticed a small swelling the size of a pea below the superior margin of the left orbit. The tumor gradually increased in size without the least pain and without inflammatory phenomena. When seen by Valude she presented a small prominence at the middle of the upper eyelid, the prominence was of such a size as might be caused by an

object the size of a hazel-nut under the skin. To the touch the tumor felt fairly firm and was prolonged under the orbital margin outwards till it was lost in the depth of the orbit. It did not appear to be adherent either to the eye or the walls of the orbit, there was no exophthalmos and the movements of the eye were easily executed. The eye itself was normal and the visual acuity was good.

After an incision of 3 cm. in length over the prominence of the tumor, a smooth mass was found extending backwards into the superior part of the orbital cavity. The mass, which terminated in a thin extremity, was cut through at a depth of 2 or 3 cm. behind the superior orbital margin.

On histological examination of the tumor it was found to resemble those which are observed in the lesions which are called neuro-fibromata. A month later the patient returned well satisfied with the result of the operation, but related that she experienced a feeling of formication in the left side of the forehead; she also remarked that she did not feel when she was pricked on the left side of the head. An examination of the zone of anesthesia showed that the region of distribution of the external frontal or supra-orbital nerve was affected. The conservation of the sensibility of the palpebral conjunctiva of the upper lid proved that the internal frontal was not affected and seemed to show that the tumor did not extend as far as the principal trunk of the frontal nerve.

Orbit, Neuroma of the. See p. 8361, Vol. XI of this *Encyclopedia*.

Orbit, Nevus of the. Simple or composite angioma of the orbit is described on p. 466, Vol. I of this *Encyclopedia*.

Orbitocele. A tumor protruding from the orbit.

Orbito-extus-scléroticien. (F.) External rectus muscle.

Orbito-intus-scléroticien. (F.) Rectus internus.

Orbitonasal. Pertaining to the orbit and to the nose.

Orbito-ocular. Pertaining to the orbit and the eye.

Orbit, Operations on the. This section does not include such operations as *enucleation of the eyeball* or other procedures that do not involve the orbital walls or their coverings.

Anesthetics in orbital surgery. Although the majority of surgical procedures involving the orbit require general anesthesia, yet some surgeons employ local anesthesia in various forms, especially when the ocular or systemic conditions are unfavorable to the use of ether, chloroform, nitrous oxide, etc. Loewenstein believes that an injection of cocain solution directed towards the ciliary ganglion influences all the sensitive nerves of the eyeball and orbit. He also quotes Elschnig who performed 26 operations under ganglion anesthesia, viz. 18 enucleations, 7 exenterations and 1 cyclodialysis.

After cocainization of the conjunctiva a Pravaz (hypodermic) syringeful of a 1 per cent. solution of cocain is injected through a strong needle 5 cm. long. The lateral commissure is stretched towards the temple and the needle introduced through the conjunctiva, close to the lateral orbital margin a little below its middle point. It is then carried along the lower border of the external rectus muscle and external orbital wall, and finally lifted inwards until about 0.5 cm. of its shaft is still visible; and one-half a syringeful is injected. By slight side-to-side motions one must guard against the needle point being caught in the optic nerve or a large blood vessel. The anesthesia of the eyeball, which ought to be established within two minutes, is tested by slight pressure on the globe. If the eyeball is not anesthetized the needle is pulled back about 1 cm. and reintroduced in a changed direction. Subconjunctival injections of cocain, about 15 mm. from the limbus, are also made in inflammatory cases. Most patients were given 0.01 morphin half an hour previously, which had a beneficial psychical effect..

There was little or no pain in eleven of thirteen cases operated on and in none of them was a bad effect from the cocain observed.

Seidl (Graefe's *Archiv f. Ophthalm.*, 91, 2, 1916) resected the external orbital wall (Krönlein operation) under local anesthesia. The skin having been disinfected with tincture of iodine, infiltration anesthesia was done with about six ccm. of one per cent. novocain adrenalin solution. The injection needle was then inserted at the upper outer angle of the orbit, and about five ccm. of a four per cent. solution of both drugs one after the other injected into the anterior, middle, and lower third of the inferior orbital fissure. Six ccm. of the one per cent. solution were then injected on the posterior surface of the fronto-sphenoidal process of the malar bone, and finally the needle carried from the lower orbital fissure to the lower outer angle of the orbit to a depth of from three to four cm., and three ccm. of the two per cent. solution injected. After resection of the bone, about two ccm. of the two per cent. solution should be injected around the optic nerve near the apex of the orbit.

H. P. Cole (*Jour. Am. Med. Assocn.*, Dec. 4, 1915) describes a total removal of the orbital contents with the periosteum under local anesthesia. The patient, a woman eighty-one years old, with a recurring melanosarcoma, had also a chronic nephritis, and general anesthesia was considered unwise. A preliminary injection of scopolamin one-two-hundredth grain and morphin one-eighth grain was given one hour and a quarter before operation, and another injection of scopolamin one-two-hundredth grain and morphin one-sixth grain thirty minutes

before operation. A line of local anesthesia infiltration was made one-half inch below the lower palpebral margin and carried well down on the malar border. The infiltration was carried into the orbit and close to the orbital floor. A heavy needle was then carried back to the orbital apex and the tissues slowly infiltrated with a one per cent. novocain-epinephrin solution. About five cubic centimeters were used. Similarly the upper part of the orbit was infiltrated, and the operation was done without any difficulty.

Most of the following text and illustrations are adapted from Wood's *System of Ophthalmic Operations,* Vol. I.

Operative procedures. Before considering single operations on the orbital walls and contents it is desirable to discuss a few procedures that are common to almost all divisions of orbital surgery.

Exploratory puncture is employed for determining the character of tumors or other abnormal deposits in the orbit. It may be done with a grooved needle, a small hypodermic syringe, an exploratory trocar, a narrow Graefe knife or a pointed bistoury.

Billroth (*Chirurg. Klinik in Wien,* 1870) employed an acupuncture needle to determine, in the case of tumors, whether the bony walls of the orbital cavity were still intact. The needle was thrust deep enough and in such a direction as would in the normal condition reach the osseous structures. If no resistance is felt the conclusion is that the bony wall has been absorbed by pressure of the neoplastic growth and that the neoplasm probably extends beyond the orbit, perhaps, for instance, into the cranial cavity.

Incisions. Dividing the overlying tissues with a suitable knife is employed for the drainage of fluid or the removal of solid or semi-solid material such as orbital cysts and abscesses. It is also useful in suppurative periostitis, empyema or dropsy of the frontal sinus or ethmoid cells, as well as for hemorrhage into the orbit or beneath its periosteum. It is likewise employed for the removal of splinters (in fracture of the cranial bones) and foreign bodies; also as a preliminary to the extirpation of tumors. It is also resorted to in cutting open the fistulæ accompanying lachrymal and frontal sinus disease.

The form of incision depends upon the purpose of the operation—whether it be through the palpebral skin or by way of the conjunctival sac. The latter route is preferable because there remains no visible scar; still the orbital cavity is less accessible in this procedure and the wound cannot long be prevented from healing by the introduction of a tube or gauze drain because these dressings act as an irritating foreign body to the conjunctiva and cornea.

The conjunctival incision is made in and parallel to the fornix, is

employed in cases where only a temporary wound is required, as in the removal of foreign bodies and splinters of bone that can be felt through the conjunctival sac, as the first act in the extirpation of tumors and in some operations on the lachrymal gland.

The palpebral skin incisions should be governed by the rules laid down in the section on **Blepharoplasty.** (See Vol. II.) As a matter of fact they generally follow the outline of the orbital margin. When the foreign body or tumor is superficial the lid skin is stretched between the thumb and forefinger of the left hand while the point of a convex scalpel, directed at right angles to the skin surface, is passed through the tissues to the required depth and a clean, uniform cut made from one side to the other of the bulging body. It is more surgical to make too long a primary incision than one that requires subsequent lengthening. Subsequent incisions following the whole length of the primary cut are now made until the tumor in its capsule is reached.

In choosing the site of an incision by way of the conjunctival sac it is best, if one has a choice, to elect the lower-out aspect of the eyeball, thus avoiding what in the other localities might involve the tendons of the internal rectus the superior oblique and the inferior oblique as well as by no means of least importance—the eyeball itself.

The depth to which the incision is made will depend largely upon the resistance of the parts. Great care should, of course, be exercised in performing the operation and, above all, one must remember the depth of the orbit and never allow the point of the knife to reach the apex of the cavity.

Orbital abscess. Purulent collections within the orbit should be opened and drained at the moment (and in the situation) that fluctuation is first noticed. When eyesight or life itself—or both—is endangered by a septic collection within the orbit it is desirable to cut down upon it before fluctuation can be detected, in which case one must be guided as to the position and extent of the incision by the direction in which the globe is pressed, the character of the excursions, the variation in the resistance of the tissues about the eyeball and, lastly, by the sign of Uszynski (*Klin. Monatsbl. für pkt. Augenheilk.*, 30, 1892, p. 110)—the indentation of the eyeball as determined by the ophthalmoscope.

J. J. Evans (*The Ophthalmoscope*, April, 1908) points out that orbital abscess of antral origin usually shows at the lower-outer margin of the orbit; if from the frontal sinus, at the upper-inner third of the margin—as has been noticed for a long time by others. The anterior

ethmoidal cells correspond to the anterior half of the nasal wall of the orbit; the posterior half to the posterior cells.

Foster (*Annals of Ophthal.*, July, 1908) reports a case where incision into the orbit led to the discovery of pus that seemed to come from the inner wall of the cavity and the adjoining nasal cavities. Finally, repeated incisions revealed the zygomatic fossa as the seat of the disease, the pus stream having entered the orbital cavity through the spheno-maxillary fissure.

In urgent cases—where rapid increases of swelling, high temperature and other evidences of serious infection of the orbit declare themselves, even when one suspects the presence of a localized deposit, the foregoing observations are generally insufficient to indicate the exact locality of the septic depot. In these instances a horizontal blepharotomy should be performed and several incisions made deep into the orbital tissues to relieve the edema, permit the escape of fluids and perhaps tap the poisonous collection. Axenfeld even advises, in these desperate cases, a Krönlein operation which may expose the infected locality, permit a more thorough exploration of the orbit, the evacuation of pus and the relief of the most urgent symptoms by removing pressure on the swollen tissues. This procedure is preferable to any of the operations for opening the orbit from the nose.

Whatever means is employed for cutting down upon the septic deposit a careful search with the finger and sound should be made for disease of the bony walls of the orbit, unless another and definite diagnosis has been made. If caries or necrosis of the superior orbital wall is established the greatest precautions are to be observed and in all cases it must be remembered that the frontal sinus and the cells of the ethmoid are frequently involved in septic abscesses, phlegmon and other processes within the orbit.

Extirpation of orbital tumors. In the removal of growths in this situation one should bear in mind their size, their situation (whether they rest in the anterior or posterior segment of the cavity, whether they are within or without the muscle cone), their exent (whether they involve or have spread from other cavities), their boundaries (whether circumscribed or diffuse), their character and their origin. Finally, the state of the eye itself should be taken into consideration.

Another important question is whether the tumor can be extirpated without removal of other tissues, or whether the eyeball iself may not also require enucleation?

It must at once be seen, from the foregoing, that definite rules for dealing with orbital growths are difficult to formulate—only the principles that should guide one can be laid down. During the operation,

also, it may be necessary to vary the first plan adopted. The surgeon should, therefore, obtain the consent of the patient to the removal of the eye should he consider it necessary, before the operation is begun and especially before the employment of a general anesthetic.

For small, benign tumors, in particular cysts—situated above and well towards the front of the orbit, between the muscle cone and the levator of the lid—one should choose the incision through the conjunctival tissues at the fornix following the margin of the orbit. This procedure is confined to benign tumors. The second operation through the lid skin, is employed for the removal of benign growths within the muscle cone—fibromata and cystic tumors—as well as neoplasms of the optic nerve itself.

In the case of large tumors situated outside the muscular cone, especially those between the cone and the levator palpebræ, a combination of the lid section and the Krönlein operation greatly increases the efficacy of the former procedure. This combination not only increases the area of the operation but avoids the danger of injuring the eyeball. When possible, the skin incision should follow the upper margin of the orbit.

When one has to deal with malignant neoplasms, especially with those involving or threatening the globar tissues, quite a different method should be chosen, if, indeed, any operation is considered. This matter will be found more fully considered under **Exenteration of the orbit.**

As a rule cystic and solid tumors of the orbit operable under the rules (q. v.) just laid down are easily extirpated. The section in the skin is made just within the hair of the eyebrow when possible, so as to conceal the scar, and if the tumor has a capsule it should not be incised, but removed with the growth.

When the section is made through upper or lower sulcus more room may be secured by a canthotomy (q. v.) The conjunctival incision having been made with a small convex scalpel, the operator continues the cut to the outer canthus, or *vice versa*, a method of special value in tumors occupying the outer-upper or outer-lower quadrants of the orbital base. After the primary incision the wound edges should be separated by broad elevators, an Allport's speculum (q. v.) or similar instrument and the cutting continued with some care. The small arteries severed during the operation should be tied or fixed with small hemostatic forceps. As soon as the tumor is reached the knife should be laid aside and the growth isolated from its bed by the fingers, a blunt spoon, strabismus hook or closed scissors, not forgetting to enlarge the deep wound so that its width corresponds to the superficial

incision. By this careful form of enucleation the growth is meantime grasped and gently dragged forward with forceps or by means of a suture through its capsule, is detached from its surroundings, avoiding the use of cutting instruments except that fibrous bands are best severed with scissors close to the tumor mass. It must be remembered that it is important to remove all the tumor tissues. Care should be taken not to injure by undue pressure or otherwise the neighboring eyeball and optic nerve.

When, as in the case of dermoids, the neoplasm is firmly attached to the orbital wall, i. e., to the orbital bones, it is advisable after detaching it with scissors to curette the point of attachment; if to the periosteum alone it is sometimes possible to remove that portion attached to the tumor with raspatorium.

Having removed one tumor it must not be assumed that it is the only one present. A second or even a third may be concealed by a more superficial growth, as has been observed by several writers. Instructive papers on this subject have been contributed by Badal (*Archives d'Ophtal.* Vol. 13, p. 193) and Cornwell (*Archiv f. Augenheilk.*, Vol. 14, p. 120.)

Oram Ring (*Trans. Oph. Sec. Coll. Phys.*, Philadelphia, 1904) draws these conclusions regarding sarcoma of the orbit and its surgical treatment:

1. The difficulty in accurate diagnosis under certain conditions entirely justifies an exploratory incision with removal of a section of the growth for microscopic study, said exploration likewise serving to determine the ramifications of the tumor.

2. The brilliant results achieved by a number of accurate observers in the field of Roentgen therapy justifies the immediate tentative application of the method before any radical operation is attempted. If unsuccessful in removal of the growth, its virulence will probably be decreased and the dangers of metastasis lessened. (Leonard).

3. If the sarcoma is encapsulated, operative intervention without (complete) orbital evisceration promises a successful outcome.

4. In view of the almost constant recurrences after orbital evisceration, the removal of the growth itself is regarded as sufficient unless the periosteum or bony wall is involved.

5. The encouraging results reported from the cataphoric sterilization of malignant growths in other parts of the body seem to warrant the utilization of this method in the orbit, due care being exercised as to strength of current used.

6. Future experience must determine whether better results will be

achieved by using this method for the original growth or reserving it for recurrences in loco.

7. If operation has been performed and the growth has recurred, we have at command these two valuable methods of attack.

The indications for the operative treatment of orbital tumors in general have been pretty thoroughly discussed by Wurdemann and others, Stedman Bull among the number. The latter believes that if an orbital tumor is developed in the orbital tissue proper, in the sheath of the nerve or in the periosteum, and is encapsulated, the prognosis is good; if it is not encapsulated, no matter what its origin, the prognosis is bad. He believes that each operation tends simply to hasten the return of the growth and by so much to shorten the life of the patient. He was favorably impressed with the value of X-ray treatment under these circumstances.

Operations for the removal of tumors of the optic nerve. The removal of optic nerve tumors by the subconjunctival route was first fully described by Lagrange (*Congrés français de chirurgie,* Paris, 1892). After general anesthesia he did an external canthotomy and passed a suture through each lid so that it might be used as a retractor. Then the outer half of the bulbar conjunctiva and Tenon's capsule was dissected to the sulcus, the tendon of the external rectus divided and a thread passed through the distal portion—so as not to lose sight of it. Then, by means of the index finger or a sound [closed blunt scissors make a useful instrument for the purpose. Ed.] the tumor is isolated from its surroundings, the globe being pushed to one side and kept there by a spatula or an enucleation spoon (q. v.).

Having separated the tumor from the surrounding muscles, etc., a (Cooper's) needle armed with a stout silk ligature is passed around the neoplasm; and, if necessary, it is transfixed by another thread for the purposes of better manipulation. Now, with guarded scissors (so as to avoid the ophthalmic artery), guided by the finger, the nerve is cut through at the orbital apex. By firmly pulling on the ligature and transfixing suture the eye, tumor and nerve may be extruded from the orbit and retroverted. The nerve and tumor may now be cut off close to the globe and the posterior aspect of the latter examined. The bleeding is arrested, the parts rendered aseptic, the globe is turned around and replaced in its socket; the external rectus is resutured, the ocular coverings replaced and the wound edges in them and in the lid sewn up. Drainage is provided for several days but, as a rule, the swelling in the parts soon subsides and there is little subsequent reaction.

The globe follows the usual rule of optic nerve resection (see **Enucleation**). The eye shrinks, the cornea loses its lustre, the

pupil its reaction and the globe its normal tension. However, the result is generally better than after a partial orbital evisceration or even a globar enucleation. Moreover, the shrunken globe forms a good pad for a prothesis should that expedient eventually be chosen.

If, owing to the unusual size of the new growth it is difficult to withdraw it from the orbit it may be necessary to cut through the superior and inferior rectus after a corresponding removal of the overlying conjunctiva.

During the after conduct of these cases complications may arise that necessitate enucleation of the eyeball. Hemorrhage may force the eyeball out of the orbit and prevent its reposition. If it sets in immediately after the operation the lids may be sewed together over the globe in the hope that the pressure upon the soft parts may stop the bleeding.

Neuroparalytic keratitis is another complication which may end in destruction of the cornea, hernia of the iris and phthisis bulbi.

Braunschweig believes that the best way to avoid most of these dangers is always to do a Krönlein operation. The external rectus, when exposed, may either be pushed aside, two sutures being passed through its upper and two through its lower border. These sutures are tied and the muscle divided perpendicularly between the knots. The nerve and tumor are shelled out with the finger and treated as in the Lagrange method (q. v.).

It must be remembered, in connection with every form of optic neuroma that the eye affected is always blind and that the question of removing the tumor without sacrificing the globe is generally a cosmetic one. If the tumor is not too large or too diffuse it can generally be extirpated without sacrifice of the globe.

If it extends into the cranial cavity it is best not to attempt its removal.

Knapp (*Klin Monatsbl. f. Augenheilk.*, 12 p. 439, also *Trans. Am. Oph. Soc.*, 1879, p. 557) has described two successful operations for the extirpation of optic neuromata. He introduced an ordinary eye speculum and with a pair of strabismus scissors made an opening, up and in, along the superior fornix through the conjunctiva and Tenon's capsule between the superior and internal rectus and the superior oblique until he could outline the optic tumor with his forefinger. Under the guidance of the index finger he severed the attachments of the growth from all the surrounding tissues except the optic nerve. Finally, he cut through the nerve itself, first at its ocular, then at its distal end, and succeeded in drawing out the entire growth with the flat of the scissors. There was very little bleeding.

If it can be established that the tumor affects only the nerve sheath an attempt may be made to remove the new growth without damaging the nerve itself—and so preserve or recover some eyesight—especially as neuromata in other situations have been extirpated without entire loss of the nervous function, although it seems impossible to preserve the central vessels uninjured and, failing that, blindness is inevitable.

Although tumor tissue is often observed in the distal end of the cut nerve showing that the intracranial portion was involved, the majority of primary optic tumors are benign and do not return after being treated in this way. Salzmann (*Archiv. fur Ophthal.*, 39, 4, p. 94) has published an account of three cases of myxosarcoma (the commonest form of optic nerve tumors) in which he shows that they exhibit no disposition to perforate the orbital walls or to involve distant organs. In a very few cases the tumors are of the pure sarcoma and endothelioma type and require an entirely different surgical procedure.

Finally, Byers (*Studies from the Royal Victoria Hospital*, Montreal, Vol. No. 1, p. 3) has given a full account of primary intradural neoplasms of the optic nerve which is well worth perusal by anyone desiring complete information on this subject.

"As an example of the necessity for individual action in certain cases of orbital tumor, I was consulted in 1907 by a man, æt. 36, who had, several years before, lost his left eye by an accident. When I saw him he had a well developed carcinoma of the right lower lid and internal angle that had been treated with Vienna paste, X-rays and by various cutting operations. The inner half of the lower lid, the tissues at the internal canthus and the inner fifth of the margin of the upper lid were bound together in one cicatricial mass. So far as could be made out by a nasal examination there was no involvement of the ethmoid or antrum of Highmore, although from the symptoms and after skiagraphy there was suspicion of an extension of the cancer to the inner orbital wall and the inner-lower bony margin of the orbit. The globar excursions were greatly limited and the inter-palpebral fissure was reduced one-half; but vision was almost normal. I made a careful resection (with scalpel, blunt scissors and curette) of all the suspected tissues in the neighborhood and found that the malignant growth involved the inner wall of the orbit (which I removed) but that it was impossible without sacrifice of the eyeball to make a thorough exploration and cleaning out of the infected cavities.

"The wound of operation healed kindly and with the subsequent implantation of several Thiersch grafts the patient's appearance and comfort improved.

"In three months there was a manifest return of the disease with

involvement of the ethmoid spaces. The patient was then given the choice of complete blindness or a chance, by a complete orbito-ethmoid exenteration, of escape from impending death through extension of the neoplasm to the brain and general system. The unfortunate man chose the latter alternative and died about 18 months afterwards.''

Exenteration of the orbit—Evisceration of the orbit. Extirpation of the orbital contents may be partial or complete and either operation is required when enucleation or an osteoplastic resection is insufficient to eradicate the orbital disease.

George Bartisch (*Ophthalmodouleia*, 1583, chapter 3, p. 208) was the first to describe the medieval method for exenteration of the orbit. He gives full illustrations of the instruments employed and describes the operation, which consisted in cutting, gouging and scraping the orbital contents, with the tumor (for which the operation was then, as now, most commonly done) out of the socket.

The modern form of orbital exenteration was introduced for the first time by Arlt (Graefe-Saemisch *Handbuch der ges. Augenheilk.*, 1 Ed. Vol. III, 1, 1874, p. 434).

Partial evisceration is indicated in cases where only the soft parts are affected and includes enucleation of the eyeball and removal of certain other tissues of the orbit as, for example, a growth that threatens the integrity of the surrounding parts or the life of the patient. Some examples of this incomplete form of exenteration are described under operations on the orbital walls but in general the operation may be said to be required in epithelioma that has extended into the orbit, in the circumscribed forms of orbital sarcoma, in all malignant tumors that are confined to the muscle cone and in slight extensions of intraocular neoplasms through the scleral walls. In other words, the exenterated tissues are only those directly involved in the disease.

As complete exenteration is not an operation to be lightly undertaken, owing to the deformity that follows, it is well in some cases not to decide whether the severer intervention is required until the operation is well under way, since the simpler plan may be substituted for total exenteration during any stage of the partial operation.

Complete or total evisceration or exenteration of the orbit. This serious procedure involves complete extirpation (under appropriate general anesthesia and the most careful asepsis) of the orbital contents and often includes excision of one or both lids. The entire periosteal lining is generally removed and sometimes the operation involves the opening and cleaning out the frontal or other neighboring cavity.

If the lids are to be preserved intact a canthotomy is first done to expose the outer margin of the orbit. This enables the operator's assistant to hold the palpebral borders wide apart with lid elevators or tenacula. With a stout convex scalpel the soft parts are incised down to the bone all about the orbital margin. To avoid as long as possible obscuration of the operative field the lower border corresponding to the inferior formix, is first incised; then, following the left forefinger, as a guide, the upper and outer borders receive similar attention. Now, if it is decided to do a total exenteration from the beginning the marginal periosteum should be lifted away from the bone with a raspatorium and the whole of the orbital cone, contained in it, (vessels, nerves, fat, muscles, eyeball, etc.) are carefully separated by curved scissors, curette, handle of the scalpel and the forefinger, in one mass from the bony walls to the extreme apex of the orbital pyramid. In addition to these all ramifications of the diseased tissues should be extirpated.

Unless they are involved in the disease we should spare the lachrymal sac and its extension into the nasal duct. The lachrymal gland is also avoided, although the latter is often eviscerated in the complete operation. The separation of the periosteum will be most satisfactory if carried out first on the temporal wall of the orbit, then above and finally on its inner aspect. Resistance to the elevation of the periosteum may be expected at the insertion of the internal check ligaments and the pulley of the superior oblique where the simple elevator or forefinger will have to be reinforced by the scissors. Care should be taken, while working in their neighborhood not to perforate the delicate bony walls of the orbit, especially at the thin paper-like lamina of the lachrymal bone and at the optic foramen, sphenoidal fissure and zygomatic fossa.

When the periosteal sac with its contents are entirely separated from the surrounding bony walls and are held in place only by the tissues about the foramina at the apex, they should be divided by a pair of scissors. Those instruments devised by Bettman and Worlomont (q. v.) are recommended since these combined scissors and clamp not only cut but serve to prevent bleeding which is often profuse.

The best method of limiting the hemorrhage attendant upon orbital evisceration is the gauze tampon and the hot bichloride douche, 1:3000. The latter may be freely applied and used as hot as it can be borne by the hand.

The best dressing for both partial and total evisceration is a long strip of gauze—iodoform after the removal of malignant growths, plain otherwise—gently packed and filling the whole cavity. It may be

smeared with White's ointment or with sterile vaseline to prevent adherence to the tissues. If the orbit be firmly and uniformly filled with the gauze it is not necessary to apply a roller (pressure) bandage, though it may be needed if the lids have been removed. It is well to change the dressing twice a day, douching the cavity with sublimate solution (1:3000) each time before applying the gauze.

The exenterated orbit soon cicatrizes in part and eventually fills with granulations and some surgeons take advantage of the presence of these to impose upon them mucous or skin grafts (Küster prefers skin flaps) both to protect the parts and to relieve somewhat the horrible deformity resulting from the removal of the tissues. Some of these procedures are described in this section. This cosmetic object is attained to some extent by plastic operations intended to allow the patient to wear a prothesis—a subject discussed in the section on **Blepharoplasty**. In total extirpation simple procedures are of little avail and this is the reason why it is occasionally wise to rely upon some of the operations (q. v.) for complete obliteration of the conjunctival sac or occlusion of the orbit.

Generally speaking, the ability to spare the lids and conjunctiva is the chief factor in determining the character both of the orbital exenteration and of the subsequent operation. In the following pages it will be noticed that many of the surgical methods discussed hang upon this question.

For example, the subconjunctival exenteration described by Axenfeld (*Bericht der 27 Versammlung deutscher Naturf. und Aerzte,* 1903) depends upon the salvation of all the lid structures, including their mucous lining. He does a preliminary enucleation in the usual fashion, then divides the conjunctiva horizontally to the inner canthus; Externally all the lid tissues to the outer commissure are incised. The orbital exenteration is now accomplished and the conjunctiva and lid skin carefully sutured. Subsequent treatment of the orbit is carried on through an enclosed medial opening corresponding to the recently removed cornea.

Should it be necessary to enlarge the usual sphere of the orbital evisceration on account of a large tumor, disease of the orbital walls or for involvement of the neighboring cavities, a more extensive detachment of the conjunctiva, as well as wider incisions in the lid skin may be made to meet the exigencies of the case.

Orbital evisceration done in this way lends itself to the wearing of a prothesis, especially if an artificial pad of paraffin, sponge, fat, iodoform-spermaceti, etc., can be inserted.

Busachi prefers as an after-treatment of orbital evisceration a com-

bination of the Thiersch and flap operations. First of all he covers the denuded cavity with epidermal grafts and when these have "taken" he closes the cavity with flaps from the surrounding skin. The epidermal surface is turned inwards, the fresh surface being turned outwards and covered with Thiersch grafts.

Rollet (*Revue gen. d'ophtal.*, July, 1908, p. 289) described a similar procedure, including removal of a portion of the lids, and advises it especially for extensive burns and for malignant disease of the orbital tissues.

Romano-Catania (*Archivio di Ottalmol.*, Vol. I, 1894-5, p. 209) suggests a curious procedure, a study in facial cosmetics, when both lids are sacrificed. He brings forward two thick flaps from the cheek and forehead, including between them the strip of skin containing the eyebrow. In this way the supercilia are made to occupy the position of the interpalpebral slit—thus imitating the appearance of closed lids!

If the amount of excised tissue is not too great, the defect may sometimes be supplied by such a plastic operation as the conditions in individual instances may suggest. Even when the lids are entirely removed, sufficient skin may often be furnished by the dermal covering from the corresponding eyebrow and temple.

In any event, when an enucleation or exenteration is done for malignant disease, it is better to wait until the orbital wound has fully cicatrized (as that is the best way to insure complete extirpation of the growth) before covering the cavity by any of the methods proposed. Otherwise, the operations, especially those needing transplantation of skin, may be undertaken immediately after the evisceration itself.

Prothesis after exenteration of the orbit. That an artificial eye may be worn in a cicatricial, contracted or obliterated conjunctival sac a number of operations have been devised. These include blepharoplasty and the transplantation of mucous, skin and other tissues after the manner of Wolfe, Thiersch, Gifford, Fricke, Holtz and others. They are described elsewhere (see **Enucleation** and **Blepharoplasty**) and are mentioned here only to draw attention to the fact that the principles that underlie them are generally applicable to the similar treatment of an exenterated orbit.

For many reasons it is often best to close the orbital opening entirely after a complete exenteration, but when the lids are preserved or after an operation for their restoration, an attempt may be made—as in the Axenfeld operation just described—to fill up the cavity in such a manner that it will support a prothesis.

Polya (Michel's *Jahresbericht*, 1904, p. 367) advises, for the purpose

of providing a good, solid, pad for the artificial eye, the iodoform-spermaceti mixture described by Mosetig under the name "Knochenplombe."

After completion of the evisceration, when the hemorrhage has entirely ceased, the cavity has been thoroughly disinfected and is quite dry this artificial "bone" is poured in. The lids then receive necessary attention (are stitched over the spermaceti pad or it is covered by skin flaps) and drainage at one or both canthi is provided by means of iodoform gauze or threads. The spermaceti remains in situ, is soon covered by granulations, and acts as a non-irritating and persistent support of the prothesis.

When it is possible to preserve the lid-skin Golovine (*Archives d'ophtal.*, Nov., 1898, p. 679) suggests a method for supporting an artificial eye which (it seems to the writer of this section) might sometimes be combined with the plan of Pólya.

He first shapes a cutaneous flap (A) from the temple, as shown in the figure. A semicircular incision, a-b, is made and continued to c. Through a subdermal opening, that communicates with the orbit along a-b, the upper, rounded end of the large flap is slipped and the remaining tissues rearranged as in the figure. The sliding flap, applied and arranged within the orbit (epithelial surface outwards) is carefully stitched to the cut edges of the remaining conjunctiva and so a space is formed in which the prothesis may rest.

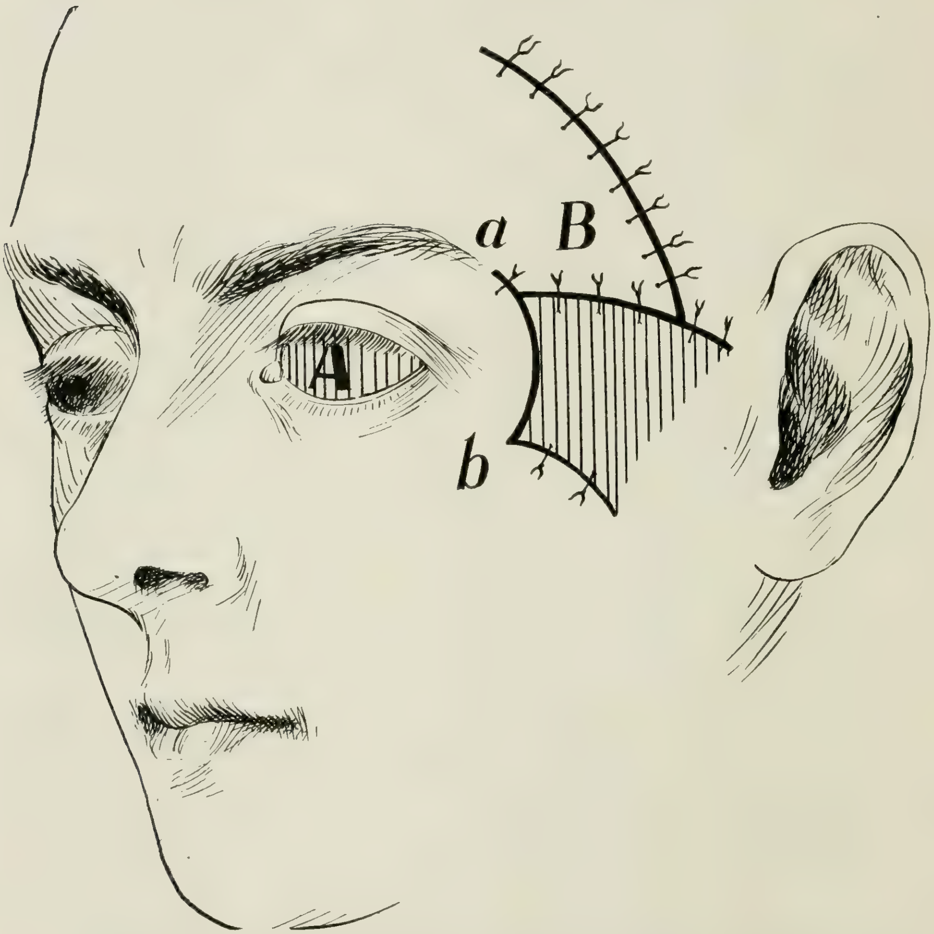
Operations for covering the interpalpebral entrance and relieving the deformity following eyeball enucleation and orbital exenteration. If the lids are preserved, as in some enucleations of the globe and in partial exenteration of the orbit, the subsequent cicatricial contraction is prone to draw their margins inward and to add to the deformity.

Beard (*Ophthalmic Surgery*, p. 615) was able in the case of a young woman with recurrent sarcoma of the lachrymal gland after enucleation and partial exenteration had been resorted to in vain, to save the lids and conjunctival sac. The incision extended from about 2 cm. below the outer canthus and around the superior margin to the median line of the nose. The flap thus outlined was dissected up without injuring the conjunctiva, the exenteration made and the flap replaced.

Still these are cases, especially following exenteration, in which it is not only impossible to wear an artificial eye but patients are much annoyed by the epiphora, conjunctival secretion and the disfigurement of the sunken lids and wide-open palpebral fissure. This unsightly and irritating condition is further aggravated by the fact that the lachrymal apparatus does not afford drainage for the tears and mucoid

discharge that are sometimes secreted in abundance from the abnormal cavity.

Among the recorded attempts to remedy this sad state of affairs may be mentioned those of J. F. Streatfeild, J. Green, Alt, Edwyn



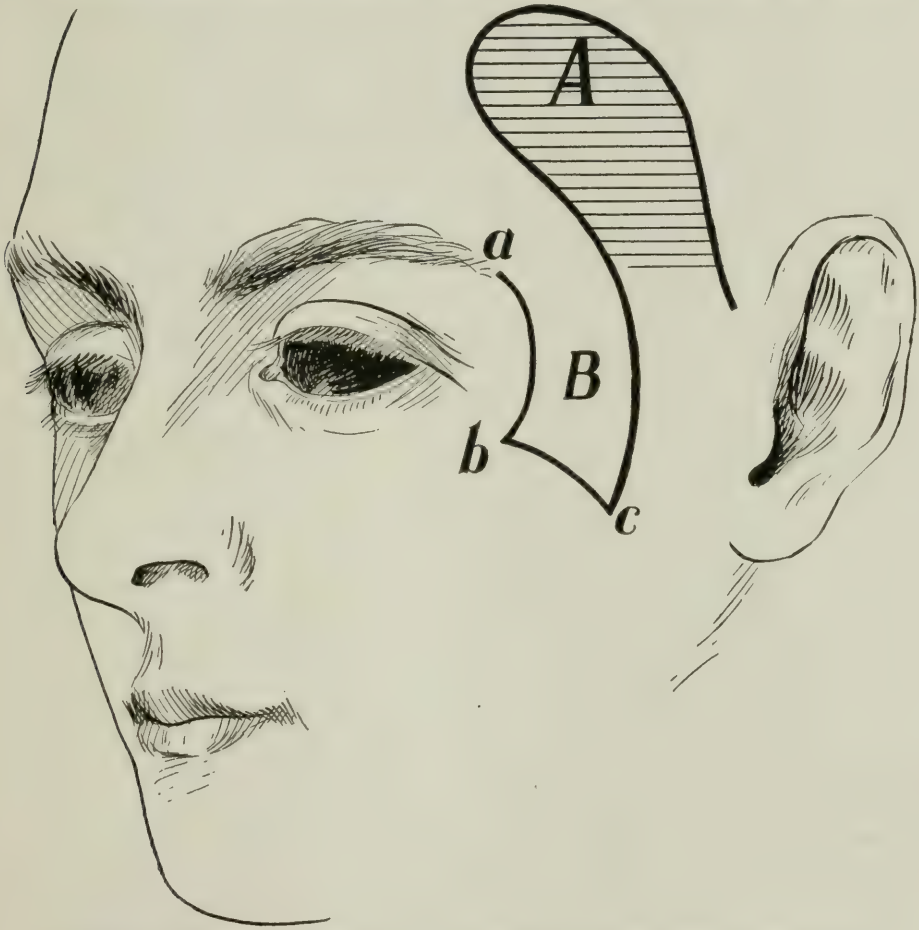
Golovine's Operation for Securing an Artificial Eye after Exenteration of the Orbit. The primary incisions.

Andrew, Küster and others. These surgeons mostly sought to remove the secreting surfaces and borders of the conjunctival sac and to close the naked orbital cavity.

The removal or destruction of the conjunctiva and the subsequent obliteration of the sac, intended to relieve the local infection and

cover a disfiguring cavity, was first undertaken by J. F. Streatfeild. He states the case as follows:

"Some patients, again, are met with, whether in private or hospital practice, who either before or since the excision operation are quite



Golovine's Operation for Securing an Artificial Eye after Orbital Exenteration. Suturing the skin flaps in position.

incapable and cannot by any surgical method be made capable of wearing an artificial eye, even if they desire it; such are the cases of irregular cicatrization within the lids, caused by wounds or burns, or ill-surgery, and producing obstinate entropion, strong cicatricial bands in any direction (that cannot be isolated by a probe passed beneath them) or a narrowing of the whole conjunctival sac or of the

palpebral aperture by any of the above means. It is a disgrace to surgery not to close up the ugly chasm and it is easily done.''

Streatfeild at first excised with forceps and scissors all the conjunctiva he could reach, and destroyed the remaining mucous membrane with caustics—zinc chloride, etc. Later, he suggested that it is desirable at the time of an enucleation or partial orbital evisceration to close the interpalpebral space and described the following successful operation he performed for the purpose:

''The lower lid being held down and strongly everted by the forefinger of an assistant, the conjunctiva was cut through close to the free margin of the lid, and dissected off the tarsal cartilage; the conjunctiva was next cut through at the outer and inner canthus. The globe was then drawn well downwards and the fold of conjunctiva between it and the upper lid dissected from the subjacent soft parts, but as the conjunctiva could not easily be separated from the upper lid it was left to be removed by caustics at some future time. In this manner all the conjunctiva, with the exception just named, was dissected up. The extirpation of the globe was now completed in the ordinary manner. Later, he notes that the soft parts of the orbit are granulating and are drawing the lids closely to them.''

John Green by preparing and suturing the lid lining and margins has much improved these earlier operations which he and Alt do in the following fashion:

The tarsal tissues and conjunctiva are drawn forth with forceps and resected from the skin and muscle. Then the lid margins are excised, all the lashes removed and the wounded edges perfectly coapted and carefully stitched together. The result is a continuous cutaneous surface covering the orbital entrance and presenting a barely perceptible linear scar where was once an unsightly opening. Alt believes that ''the freedom from continued secretion and irritation from the unsightly empty orbital cavity, the fact that by covering the orbit new irritations and, perhaps, with them sources of relapses are definitely excluded, seem to make this mode of operating one which should be more frequently employed.''

Evidently unaware of the prior and (in the Editor's opinion) more effective method of John Green, Andrew, in 1885, suggested the following improvement on the Streatfeild operation:

''An incision is made with scissors into the ocular conjunctiva; half an inch from the corneal margin, and this incision is carried around the ball; the conjunctiva is now freely detached all round, until the edges of the lid-cartilages are reached, when the conjunctiva at the inner angle of the eye, with the caruncle, etc., is most carefully re-

moved, as this is the only part where some difficulty of healing sometimes takes place; the conjunctiva of the outer angle is now similarly dealt with, the edges of the palpebral angles pared, the cartilages entirely dissected away, and a sufficient strip of the free borders of the lids removed, to include all the roots of the lashes, and lastly the ball is excised; the lids are merely brought into apposition, or the palpebral opening may be lessened by one or two sutures at each end, leaving the centre for drainage. It is advisable that the various steps of the operation should be carried out in this order, so that the bleeding may less obscure these manipulations."

Orbito-sinus exenteration. Golovine's operation. Golovine (*Annales d'oculistique*, Vol. 142, Dec., 1909) has devised a plan for the extirpation of those malignant neoplasms, especially epithelioma of the lids, that develop at the internal angle of the eye, penetrate the orbit and involve one or all the neighboring sinuses. The ethmoid, maxillary and frontal sinuses are particularly the object of this surgical intervention. It has for its object the conversion of these cavities into a single large space, thus allowing complete extirpation of the disease which otherwise would be extremely difficult or impossible to reach. After thoroughly cleaning out the cavities in question, the opening is closed by extensive skin flaps.

Golovine divides the operation into the following steps:

1. Upon proper general anesthesia and asepsis outline incisions (See figure) are made about the diseased orbit, (a) the internal vertical following the lateral margin of the nose and reaching from a point 2 to 3 cm. above the glabella, (parallel to the naso-labial fold) to 1 cm. below the ala nasæ; (b) the external vertical incision, a slightly curved line shorter than but almost parallel with the first. It terminates below at the alveolar processes, (c) the horizontal superior incision joining line *a* with line *b* and corresponding to the upper border of the eyebrow; (d) the horizontal inferior cut depends somewhat upon the ravages of the tumor, but generally corresponds with the inferior margin of the orbit. It will be seen that the total incision takes the form of an H with double crossbars.

2. Total exenteration of the orbit (q. v.) is now done in the usual way, the parts being removed, if possible, in one portion. The orbital walls can then be carefully examined and the ravages and extent of the neoplasm better determined.

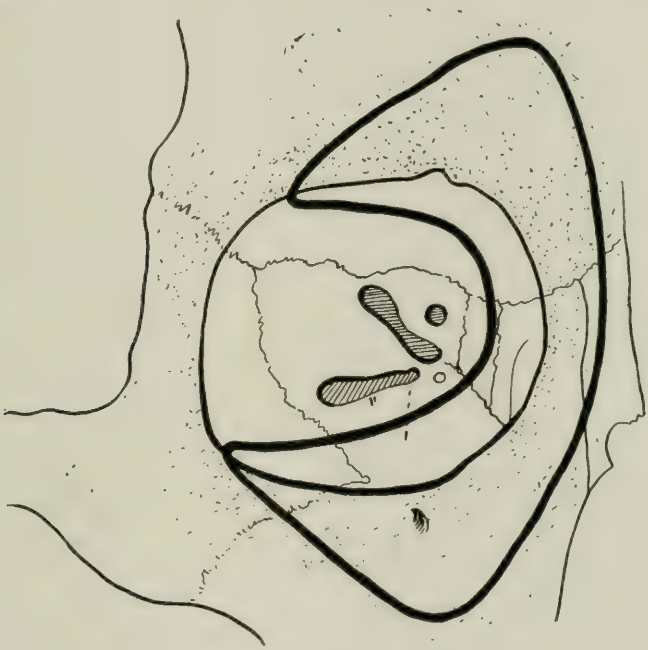
3. Exenteration of the sinuses. In carcinoma beginning at the internal angle it is generally the internal and inferior walls of the orbital cavity that are involved and, consequently, the nasal and maxillary cavities are first and most frequently invaded. Hence it is upon these

Exenteratio Orbito-sinualis. Incision of the Soft Parts. (Golovine.)

that Golovine first operates. With scissors and curette he raises successively the anterior and superior walls of the antrum of Highmore, the lachrymal bone, part of the nasal bone, as well as the nasal process of the frontal bone, the thin lamina of the ethmoid and, finally, the anterior walls of the frontal sinus.

On opening the nasal cavity the tissues generally involved by the neoplasm are to be removed. As a matter of fact, the whole ethmoidal

labyrinth, including all the cells down to the anterior wall of the sphenoidal sinus, should be taken away, and even the apparently sound tissues thoroughly curetted. If this is done it is less likely that ramifications of the tumor may remain. The posterior wall of the maxillary and frontal sinuses, as well as the remains of the orbital walls, are removed in such a way that these cavities are converted into one common space.



Exenteratio Orbito-sinualis. Line of Removal of Bony Parts. (Golovine.)

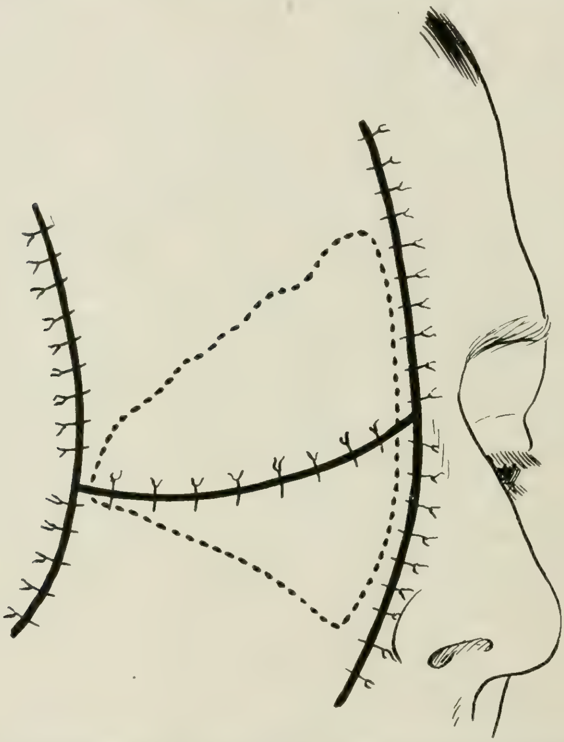
This exenteration is always accompanied by profuse hemorrhage and, in addition to the ordinary means of hemostasis, it is generally necessary to turn the patient well over on his side or on his face to prevent suffocation from bleeding into the post-nasal space.

It will thus be seen that the operation involves all the cavities as far as it is safe to carry such an operation and represents the possible maximum amount of interference in these very grave cases of malignant infection. However, it is rarely that there are any indications for evacuating the sphenoidal sinus.

The new cavity is thoroughly tamponed with simple sterilized or iodoform gauze and the ends introduced into the nasal cavity. Subsequent treatment of the parts is carried on by this route.

4. Plastic operation. The musculo-cutaneous flaps from the forehead and cheek are approached by undermining and sliding them towards one another. They are then sutured as shown in the figure so that the line of incisions takes the form of an ordinary H.

All the wounds generally heal by first intention and the cavity cicatrizes without further infection. Sometimes it is necessary, owing to separation of the transverse line of suture, to transplant further

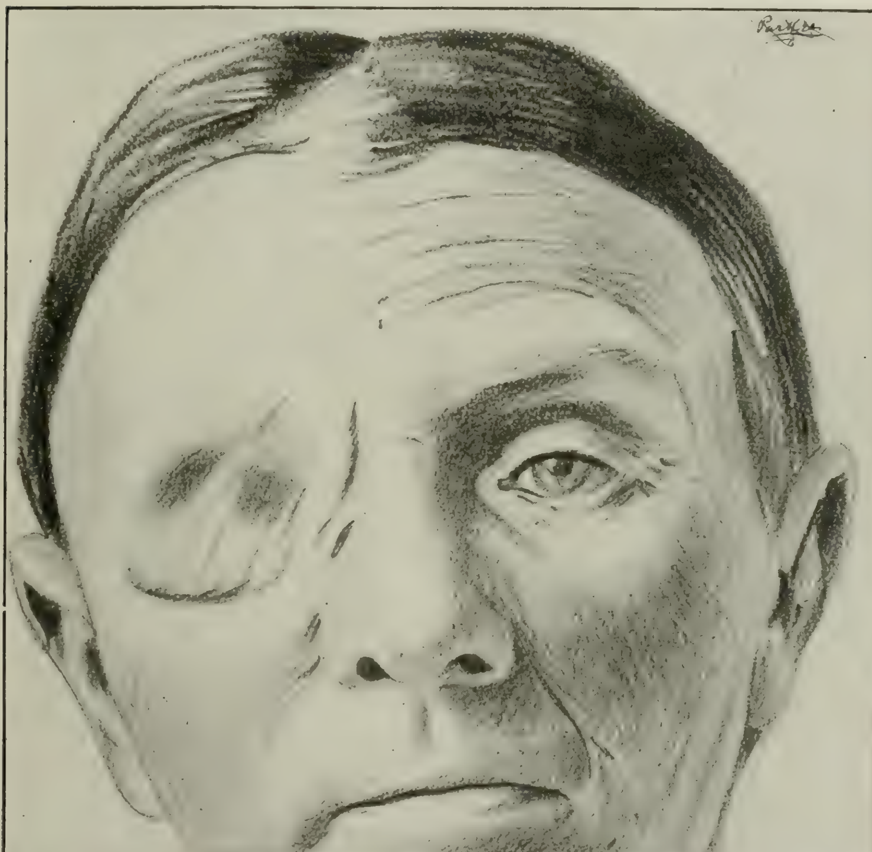


Exenteratio Orbito-sinualis. Union of Skin Flaps over the Exenterated Cavity. (Golovine.)

tissue. Probably the large cavity produced by the operation fills up with bony tissue, the skin adhering to the bone beneath. As a rule the cosmetic result is good as shown, for example, in the figure.

Extirpation of cysts of the orbit. Perhaps the tumors most difficult of removal in their entirety are large, thin-walled cysts with numerous fibrous attachments to surrounding parts. These growths are easily punctured, and call for the greatest care if one is to succeed in extirpating them. In the case of echinococcus cysts or others that answer this description, it is, on the whole, better to abandon the attempt to

remove the cyst wall, but after thorough evacuation of the cyst cavity, to inject it with a strong antiseptic. Elschnig (*Augenärtzliche Operationen*, Vol. I, p. 414) advises a 10 per cent. solution in glycerin of iodoform. Swabbing with absolute alcohol or a mixture of the same liquid



Exenteratio Orbito-sinualis. Cosmetic result. (Golovine.)

with 10 per cent. each of tincture of iodine and carbolic acid is effective. In either event, subsequent drainage must be provided.

As before mentioned, large, solid, as well as deeply-placed tumors of the orbit can only be properly dealt with after (temporary) resection of the temporal wall of that cavity. Only in this way can damage to the eye be avoided and a sufficiently large wound provided both for the intraorbital operation and for the extraction of the growth without undue dragging on the optic nerve.

The final state of the eyesight after these procedures will, of course, depend upon the degree of vision before the operation, and the damage done to the muscles, the ocular interior, the nerve supply and the tunics of the eyeball.

Tumors within the muscle-cone are chiefly cavernous angioma and new growths of the optic nerve. Intraocular neoplasms that burst through the globar wall and invade the funnel-shaped space between the straight muscles and the eyeball are malignant in character and we are interested in them, so far as operations are concerned, only from the standpoint of exenteration of the orbit (q. v.).

Angioma of the orbit and its treatment. When in the anterior aspect of the orbit, this new growth may be treated by extirpation, galvano-puncture or injections of alcohol, the last after the manner of Gifford and others. Angiomata that are confined to the lid proper (skin, conjunctiva, tarsus) may be removed in their entirety. If both the orbit and the lids are involved it is best to deal first with all the former only as the palpebral growth sometimes atrophies when the intraorbital portion of the tumor is extirpated. If it does not it can be dealt with as recommended under angioma of the lids. Deeper and larger angiomata external to the muscular cone must be removed by the aid of a Krönlein operation, although the Lagrange procedure may be sufficient if too much pressure upon the globe and too much injury to the nerve can be avoided. If the eye be blind or if a dangerous hemorrhage sets in, the eye may with advantage be enucleated.

The so-called ''cavernous'' angiomata generally develop within the funnel-like cavity formed by the orbital muscles. In this situation their extirpation invariably calls for removal of the eyeball; if outside the muscle-cone, an attempt may be made to exsect them either by the Krönlein method as adopted by Samelsohn (*Berlin. Klin. Wochenschr.*, 1880, p. 13) or even by an incision through the fornix, as in a case described by Ahrens (*Klin. Monatsbl. f. Augenheilk.*, 1889, 27, p. 260).

Arterial ligation in orbital disease. Although it is not really a part of ophthalmic surgery, ligature of the common and internal carotid arteries has such intimate relations with operations on the orbit that it must be mentioned here. One or other operation is, according to Czermak (*Augenärtzliche Operationen*, I, p. 420), indicated by the following ocular conditions:

1. In the so-called pulsating exophthalmus. Before resorting to operation, however, digital compression should be tried as in some cases it cures the disease and in others increases the efficacy of the arterial ligation. See **Exophthalmos, Pulsating.**

2. In pulsating angioma, although the prognosis in these cases is not encouraging.

3. In orbital aneurism, especially aneurysma cirsoideum, if the removal of the diffuse blood vessels is impracticable.

Siegrist (*Archiv f. Ophthal.*, 1900, 50, p. 511) advises in the foregoing cases always to make use of digital compression (as a preliminary procedure) so as to induce collateral circulation within the areas supplied by the vessel about to be tied, as well as to accustom the heart muscle to the new circulatory conditions. It is generally a good practice, also, to do the much less serious operation of ligating the internal carotid. If this fails one may proceed to the tying of the common carotid.

4. In serious hemorrhages, unchecked by ordinary means, following operations on the orbit. This formidable situation is sometimes met either after enucleation of the eyeball, exenteration of the orbit or after severe injuries involving also the neighboring cavities where the blood pours out of the nose and mouth and it is impossible to locate the source of the bleeding.

To this category may be added some cases of intraocular hemorrhage threatening complete loss of vision.

Failure of carotid ligature to cure a pulsating orbital angioma may be due to conditions à priori incurable by these means.

An example of this is seen in a case recorded by Jack (*The Ophthalmic Record*, Oct., 1907, p. 463). A female, aged 54, bumped her right temple against a door; no attention was paid to it. Two days later the writer noticed that the lid and tissues about the eye began to swell, with increasing exophthalmos of a pulsating character. The condition became rapidly worse. A pressure bandage over the carotid was of no service, and the pain became intolerable. The common carotid was then tied. The eye symptoms improved, but the general condition grew worse, and death followed four weeks later. The postmortem findings showed a sacculated aneurism of the right internal carotid artery which had burst into the cavernous sinus.

Pulsating exophthalmus. Pulsating angioma. The commonest operation for all forms of this condition is ligation of the common, internal or external carotid. Ligation of the arteries of the neck has been successful in numerous instances. For particulars of the operation see **Exophthalmic goitre**; as well as p. 4860, Vol. VII of this *Encyclopedia*.

Among the reported cases are two by Würdemann (*Annals of Ophthal.*, April, 1903) and Bull (*Trans. Am. Oph.* Soc., 1903).

In Würdemann's patient the condition seemed to have arisen spon-

taneously, a "sudden snap in her head" being felt while she was in a constrained position. This was immediately followed by dizziness and vomiting, and later the bruit, protrusion of the eye, headache and other symptoms of this condition, which had continued for one year.

Bull's patient was rendered unconscious by a blow on the head. The next morning he noticed the roaring noise, and on the second day protrusion of the eye and swelling of the lids. He was first seen a month later, when enormous distension of the retinal and conjunctival veins was a striking feature of the case. Both cases were probably typical examples of the spontaneous and traumatic forms of rupture of the carotid into the cavernous sinus, or other form of arterio-venous aneurism.

Travers was probably the first (1805) ophthalmic surgeon to bring this means of treating pulsating exophthalmus to the notice of the profession. Of the case he reported, Mackenzie, says:

"The bold and successful practice of Mr. Travers, who, for an aneurism by anastomosis, within the orbit, tied the common carotid artery, has been followed by Mr. Wardrop in several cases of this disease, situated externally.

"The only other mode of treatment likely to impede the progress of an anastomotic aneurism within the orbit, is diminution of the force of the circulation through the tumor, by applying a ligature on the common carotid artery. We owe the first proof of the efficacy of this plan, not only in preventing the increase, but even in effecting the cure of this disease, to Mr. Travers."

Probably the conclusion of Golovine (*Zeitsch. f. Augenheilk.*, Vol. 4, 1900, p. 199), who has had considerable experience in these cases, may be given, particularly as regards their operative treatment. He believes that the combination of ligation of the common carotid with ligature of the orbital vessels is the last word in the treatment of the most pronounced form of pulsating exophthalmus.

He sums up the arguments of his paper thus: 1. The operation suitable for a given instance should depend upon the peculiarities—especially the symptoms—of the case. 2. When the cerebral signs and symptoms are prominent (vertigo, noises in the head, pulsation), ligature of the carotid should form at least one part of the procedure. 3. If the symptoms are confined to the orbit then tying the orbital vessels will generally bring about a cure. 4. In litigation of the superior ophthalmic vein it often suffices to reach it by an incision beneath the eyebrow but in other instances a Krönlein operation is required. 5. In failure of carotid ligature or tying the ophthalmic vein to cure the case, or when a recurrence of the disease is to be treated temporary

restriction of the external wall of the orbit should be employed. 6. Ligature of the remaining common carotid (in failure or recurrence) is not to be recommended owing to [the danger of death; see Howard Hansell's (*Jour. Am. Med. Ass.*, 44, 1905, p. 536) report. Ed.] the serious disturbance of the cerebral circulation. 7. Some form of resection of the temporal wall must be employed if, in addition to the pulsating exophthalmus, there is the slightest suspicion of orbital tumor.

Gifford's (*Ophthalmology*, October, 1907, p. 20) further experience leads him to welcome any effective method of dealing with these cases which is free from the dangers attending ligation of the carotids. In at least a respectable proportion of cases ligation of the ophthalmic vein is effective; Gifford thinks that when decided indications of a distended vein can be felt in the orbit this operation will eventually be the operation of choice. Whether additional observation will show that it is entirely free from danger remains to be determined. The alarming symptoms which followed the operation in the cases of Lasarew, Sattler and in the writer's own case, both after the first ligation of a superficial vein and later on, coincident with the spontaneous thrombosis of the orbital vessels, indicate that the danger of fatal thrombosis of the brain sinuses cannot be absolutely denied. No fatal case has yet occurred, but in recommending the operation the possibility of such an event should not be lost sight of.

Although ligature of the common or internal carotid is the usual method employed in the attempt to relieve the various forms of pulsating exophthalmus, yet ligation of almost all the large vessels that supply the arterial or venous aneurism has been at various times recommended. Noyes (*Trans. American Oph. Soc.*, 1881, p. 308) cured a case by tying the angular artery and the inferior orbital vein. Golovine (*Zeitschr. f. Augenheilk.*, Vol. 4, 1900, p. 187) was the first—in 1887—to control this serious condition by the ligation and excision of the superior ophthalmic vein.

Beauvois (*Recueil D'Ophtalm.*, June, 1907) highly recommends and has reported two successful cases in which he used gelatine-serum injections in this disease, after the manner of Lancereaux and Paulesco.

These surgeons presented their report to the French Academy of Medicine in June, 1897. The solution which they made use of is manufactured as follows:

White gelatine ....4 to 5 grammes.
7 per cent. solution of sodium chloride..............200 cc.

The solution is sterilized in a water bath and its temperature raised to 120 degrees C. It is desirable to prepare in advance a number of bottles containing the sterilized fluid, which should be kept at a temperature of 38 degrees so as not to permit the gelatine to solidify before using. When required for injection beneath the skin it is drawn into a syringe capable of holding 500 cc. and the whole sterilized at 120° C., or by simply keeping it in boiling water for a quarter of an hour. The field of operation, preferably the buttocks, should be very carefully sterilized. The needle of the syringe is then deeply plunged into the tissues so that its point reaches the underlying aponeurosis. The injection should not be made too rapidly, but should be completed at the end of a quarter of an hour.

Carried out in this way the injection, contrary to what might be expected, is not painful. Absorption takes place rapidly and is not followed by any local or general irritation. The effect, also, is marked; the patient should be kept on his back and the aneurism should not be touched after the injection. All sudden movements on the part of the patient should be discouraged.

The injection should be repeated every six to eight days until the obliteration of the sac takes place.

When it is important to establish a collateral circulation it is better to employ solutions still weaker, namely, one to one-half per cent., and to permit an interval of from eight to ten days to elapse between the injections.

Lancereaux insists that the quality of the gelatine shall be above suspicion. He uses that known in commerce under the name of gélatine blanc-mange which makes a bluish solution. Beauvois remarks that Lancereaux has never had a serious accident following the hundreds of injections that his pupils and he have given in the treatment of aneurism.

Harold Gifford's (*Ophthalmic Record*, April, 1899, p. 174) interesting case leads us to believe, with de Schweinitz and him, that when a cautious exploration of the affected orbital vessels results in the discovery of a specially enlarged vessel it should be selected for ligation. This observation greatly simplifies the operative treatment of these serious cases; and indeed, ligation of the most prominent orbital vessel or vessels might be regarded as the first care of the surgeon, and should be practised before more formidable methods are considered.

Taylor (*Trans. Oph. Soc. U. K.*, Vol. 25, 1905, p. 177) reports a case in which the common carotid was tied with success. After four years there had been no recurrence of the disease. Brewerton points out that ligation of the internal carotid, instead of the common carotid as

usually advised, is less frequently followed by cerebral symptoms and, in his opinion, is more likely to be followed by cure.

In a case due to trauma R. Sattler (*Klin. Monatsbl. f. Augenheilk.*, July, 1905, p. 1) dissected out the aneurysmal sac in the orbit, ligated each end of it and excised the whole mass. Complete relief followed. As the tumor was favorably situated it was not necessary to do a Krönlein operation. In order to prevent too free hemorrhage a ligature was passed around the common carotid.

de Schweinitz and Holloway (*Trans. Coll. Phys. of Phila.*, 1907) report a case of orbital aneurism in which the right common carotid was ligated for the relief of pulsating exophthalmos April, 1900, and the left internal carotid in February, 1901. In both these operations there was temporary improvement. Later the symptoms returned and nearly three years after the last operation the patient, while playing football, received a blow on the head and immediately afterwards noticed cessation of the bruit.

These authors have collected and analyzed three hundred and thirteen undoubted cases of the disease and have considered, amongst other things, the treatment, which they have divided into ligation of the larger blood vessels of the neck; operations on the orbit; compression of the common carotid; direct compression of the venous swelling of the eyelids and angle of the orbit; gelatine injections; the administration of drugs and rest in the recumbent posture. They have reached the following conclusions with regard to the operative treatment: "In the presence of true pulsating exophthalmos surgical procedures should take precedence, and time is probably wasted by an attempt to cure the lesion by the administration of drugs, although injections of serum gelatin may be considered if the presence of an aneurism of the ophthalmic artery is known to exist.

Of the ligations of the neck arteries the best results are liable to follow ligature of a common carotid, as the contention that ligature of the external and internal carotid is the preferable procedure is not borne out by the statistics. If there is failure to relieve or cure the symptoms by the ligature of one carotid before the second carotid is tied, the orbital operation of dissecting out and tying the distended vein should be tried.

In the presence of a distinct venous swelling in the orbit, with evident distension of the angular or superior ophthalmic vein, the operation of choice should be isolation, ligature, and resection of this venous channel, inasmuch as thus far, although the operations are few in number, they have been uniformly successful."

The treatment of orbital angioma by galvanocautery is not to be

recommended except in those rare cases where other procedures are useless, such as, for example, deep-seated angioma whose extirpation is attended with difficulty.

Encephalocele and its surgical treatment. Berlin, in 1880, placed these tumors of the orbit among inoperable growths, but improvement in the technique, and particularly the observance of aseptic precautions, have brought surgical intervention in their behalf within the province of the operator. We are mostly interested in sincipital tumors and the removal of the whole sac with its contents has been recommended by Bergmann (*Die chirurgische Behandlung von Hirnkrankheiten,* 1889, p. 11).

Naso-orbital encephaloceles, including encephalocele and hydrencephalocele, are the commonest variety with which the ophthalmologist has to deal, although the prognosis in both instances is by no means encouraging.

In dealing with small encephaloceles an incision is made through the skin and muscular coverings at the most prominent part of the tumor, or if that is undesirable owing to degenerative changes, the opening may be made elsewhere. The sac is generally of a transparent scar-like quality and is often the seat of vascular changes, like a telangiectatic angioma. The meningeal coverings are wanting in some cases so that the tumor is in direct contact with the brain substances.

The encephalocele is, as a rule, easily separated from the surrounding tissues back to its pedicle which, after ligation with catgut, is cut through close to the bony foramen, the tumor removed, the skin wound sutured and an antiseptic dressing applied.

Large-sized encephaloceles require an extensive procedure. Two semi-circular skin flaps are fashioned at the base of the tumor to cover the defect caused by its removal. These are turned back, the pedicle exposed and cut off 2 or 3 cm. from the bone. The borders of the sac are stitched to the opening in the cranial cavity and it is often necessary to reinforce this covering by a second one. In this operation protruding brain matter involved in the tumor should be removed with it.

Elschnig remarks that the operation is contra-indicated in abnormally small skulls—"frog-head:" in marked hydrocephalus, and in complications with other malformations that threaten the life of the child.

Operations on the orbital walls. Although it may with some truth be asserted that operative procedures affecting the bony walls of the orbit are in some cases more properly within the province of the rhinologist or the general surgeon, because in these instances the

osseous structures are involved secondarily by growths or disease originating outside the orbital cavity, yet the ophthalmic surgeon should be prepared to deal with this contingency as one of that series of surgical interventions that may be carried out by any one of the three. In other words, orbital surgery is sometimes neutral ground that touches or includes several specialties, is common to them all and that may with equal propriety be occupied by all. In any event, whether the ophthalmologist elects to do the work himself or calls in his brother rhinolegist or general surgeon, he should at least be acquainted with the technique of the proposed operation. For any or all these reasons the whole range of orbital operations, as well as their preliminary and after treatment, has been rather extensively treated in these volumes.

It is premised that all the operative measures about to be described are subject to the ordinary surgical rules of asepsis, anesthesia, hemostasis and dressing, and that the preliminary preparation and after treatment must be carefully planned and carried out as in any major operation upon similar tissues elsewhere in the body. These important matters are not only fully discussed elsewhere but special reference to them will be found in connection with individual operations whenever occasion calls for it.

Operations for the relief of caries and necrosis of the orbital margins or walls. Both these processes affect most frequently the lower-outer margin of the orbit and are generally accompanied by a fistula surrounded by unhealthy or granulating tissue.

The fistula should be thoroughly exposed throughout its whole length, the incision extending beyond the external skin, the edges of the wound separated by hooks and the diseased bone scraped with a sharp spoon. If the use of the raspatorium is not sufficient to remove the carious tissues, the hammer and chisel should be employed until only healthy bone remains. One should bear in mind the cause of the local disease. It is sometimes due to syphilis, for example, and the treatment of such a case is, of course, obvious. In any event, the general conduct of these cases is always important.

The local treatment of the surgical wound is that of bone wounds generally. Iodoform gauze dressings after the careful readjustment of the soft parts by means of sutures are the main indications. The depressed scar that always follows the healing of the operative wound may be dealt with by various operations—osteoplastic and other—that are fully described in these volumes. Perhaps the following method of meeting the disfigurement is the most effective.

Mosetig's method of preventing deformity after orbital exenteration

and bone curetting. Instead of waiting until the wound has healed and then dealing with the defect in the tissues by a plastic operation an attempt to supply a pad of "artificial bone" may be made. Mosetig (*Deutsche Zeitschr. für Chirurgie*, 1904, 71, p. 419) proposes to accomplish this end by treating the freshly made wound as follows: After the primary procedure is completed, the bone wound smooth and the bleeding entirely stopped, the field of operation is irrigated with a 1 per cent. formalin solution. As soon as the bone surface is quite dry (and this result may be hastened by holding near it the Paquelin or electrocautery), the wound is filled with the following mixture (Iodoformknochenplombe), sterilized in a water bath and then sufficiently cooled:

℞ Iodoform, 60.0; spermaceti, olive oil, of each, 40.0.

The periosteal wound is closed with catgut, the skin incision with silk sutures. The curetted fistulous canal in the soft parts (or orbital cavity) is filled with strands of iodoform gauze. In the absence of a fistula, this drainage is inserted at the lowest angle of the wound. An iodoform dressing is now applied and renewed at each dressing. As long as there is any secretion from the wound or while particles of the spermaceti compound come away, the artificial drainage must be continued, after which the iodoform threads may be removed. On the eighth day the silk stitches can be taken out.

Resection of a portion of the orbital margin. The surgeon is generally required to perform this operation in depressed and healed or partially healed fractures of the orbital margin with deformity. This is especially true when a neighboring cavity is encroached upon or where ectropion, entropion or lagophthalmus is the result of the injury. The depressed bone should be exposed by dissecting and carefully freed from its bony attachments—using for the latter purpose bone scissors, the electric drill and saws. These instruments will generally be found more satisfactory than the hammer and chisel of the older surgery, since splintering of the osseous structures and injury to the soft tissues can be more readily avoided.

Once separated from its adhesions the bony section is lifted from its bed and secured in its normal position by periosteal stitches or metal sutures.

If the depression is considerable the orbital margin may be restored by the method of Gayet (*Archiv. d'Ophtal.* 1892, p. 193), who with a dentist's drill makes a row of perforations beneath the affected bone, afterwards joining them with the chisel or saw; or, with the electromotor circular saw alone, thus freeing the bone from its abnormal position. It is afterwards sutured in place by means of a metal plate.

It is quite evident that the technique of these operations will vary greatly in individual cases. In every instance the position of the soft parts—especially of the nerves and blood vessels—must be duly considered. Supplementary plastic operations on the soft tissues may also be required to complete the cure.

Resection of part of the orbital walls. In the majortiy of cases this procedure is demanded as part of an operation for the removal of tumors or in conjunction with operations on the neighboring cavities. Less frequently it is employed in the extraction of foreign bodies, including splintered bone, that have become firmly imbedded in the orbital framework, producing irritation or inflammatory symptoms.

The instruments employed in orbital osteotomy (q. v.) will also be found useful in resection—especially the various drills and saws (q. v.) that are generally a part of the dentist's armamentarium—when used with care and after a study of the parts involved are more effective and no more dangerous than the chisel and hammer. Bone scissors of various sizes and patterns will also be found useful.

The operation itself consists of cutting down to and exposing the region of the proposed resection, avoiding as far as possible important structures and elevating only the periosteum covering the bone parts to be removed. The bloodvessels may be cut in almost any orbital region as their anastomosis is abundant, but the nerves, the muscles with their attachments and the body of the globe itself must be sedulously avoided.

One should particularly bear in mind, at the base of the orbit, the nervous supply to the orbiculars (fibres of the facial), the frontalis, the supraorbital and the infraorbital nerves. In the upper aspect of the orbit lies the lachrymal gland with its various coverings, at the middle-inner aspect the pulley of the superior oblique muscle and on the upper maxillary the origin of the inferior oblique. Still further behind and at the orbital apex, the optic nerve, the nerves that pass through both the superior and inferior orbital foramina, as well as the origin and the common tendon of the straight muscles that have their attachment about the optic foramen.

Especial care should be observed in doing a resection along the lateral walls of the orbit lest the fibres of the facial that supply motor energy to the orbicularis be divided. Instead of making a preliminary incision through all the soft parts it is better, when feasible, to reach the bony structures by way of the bottom of the conjuncival sac—the folds of transmission. That the field of operation may be sufficiently large the external canthus may be divided, the incision extended, above or below, to the sulci and then to the periosteal surface as required.

The lids should now be widely separated by speculum or elevators in the hands of the assistant and the bleeding stopped so that the bared orbital wall may be sufficiently exposed.

Incisions through the upper sulcus for the purpose of reaching the upper aspect of the cavity are almost certain to involve the tendon of the levator palpebræ and the ducts of the lachrymal gland and should, accordingly, be avoided. It is far better to expose the upper orbital margin by means of a skin incision confined to the central portion of the cavity as the only tissue of importance there is the nerve fibres supplied to the orbicularis which, if cut, do not in this region materially interfere with the closing of the lids.

One must not, however, extend the incision too far inwards as that will involve the supraorbital and frontal nerves with their accompanying arteries. On the other hand, especially when these tissues pass through a foramen instead of a shallow notch, both nerves and vessels may be carefully isolated. The primary incision is made at the lower border of the eyebrow, through skin and muscle, the periosteum is exposed, incised, raised with the periosteal elevator, when the operation is completed with chisel, hammer, scissors and raspatorium and the unwounded organs held to one side until the resection is finished, when they are returned and, if necessary, stitched in their normal position.

Having taken care of the nerves and vessels as just described the operator can then undermine them while his assistant, with proper hooks or a specially devised speculum, exposes the whole length of the upper orbital wall.

The pulley of the superior oblique may be involved in a resection of the inner-upper wall of the orbit, but so long as it is not separated from the periosteal covering that binds it to the bone it may be chiseled out with its osseous attachment and no permanent damage done. In other words, the soft parts of the trochlea should be disturbed as little as possible.

Resection of the inner wall of the orbit may involve the lachrymal sac and check ligaments of the internal rectus. It is, consequently, better to carry the primary incision through the soft parts along the upper-inner half of the orbital margin and to raise the periosteum through this wound. This procedure will involve the angular artery and external nasal nerve, but division of these structures is not a serious matter. It must again be remembered that any considerable enlargement of the wound upwards and outwards may injure the trochlea and the frontal nerve.

Resection at the lower border of the orbit may involve the origin of the inferior oblique, the infraorbital nerve and some tendinous fibres

of the oblique. If the resection involves any considerable portion of the inferior orbital wall the whole canal with the nerve as well as a thin lamella of bone with the attached muscular fibres can be chiseled out and drawn to one side with a hook or suture until the completion of the operation.

Resection of the entire outer or entire lower wall of the orbit requires a much more extensive operation. It involves, among other considerations, the separation of the malar bone from the superior maxillary and is usually regarded as a part of general surgery. It must be borne in mind that any extensive resection of the inner-upper wall of the orbit will expose the frontal sinus and the inner wall of the ethmoid cells, while a similar operation on the lower wall will open the maxillary sinus and the nasal cavity.

Removal of bony tumors involving the orbital walls. At the outset it should be decided whether with the aid of Krönlein's operation (q. v.) with or without exsection of any part of the orbital wall, opening of one or more neighboring cavities, etc., a useful, normal appearing or movable eyeball can be preserved. If such is the case, the appropriate procedure is indicated and should be resorted to as early as possible. If, however, neither a functionating nor a sightly eye can be preserved, it is better at once to clean out the entire orbit by means of a simple exenteration (q. v.) and at the same time remove a growth that threatens the comfort and life of the patient.

One of the principal dangers attendant upon the removal of deep-seated exostoses and osteomata, even when these tumors are circumscribed in character, is the subsequent infection of the cranial cavity. This serious complication is all the more imminent if the growth affects the inner-upper part of the orbit or encroaches on its upper wall alone. Such tumors often originate in the frontal sinus or that cavity must be opened in their removal. Close at hand is the floor of the cranial cavity and its covering may be directly or indirectly involved in the operations required for the removal of these tumors. Indeed, Berlin (*Handbuch der ges. Augenheilk.* First edition, Vol. VI, p. 729), writing in 1880, opposed the removal of these bony growths from the orbit because of the high mortality—25 per cent. from purulent meningitis. In later years, however, Birch-Hirschfeld (*Bericht der Ophthalmolog. Congress*, Heidelberg, 34, 1907), gives a more encouraging prognosis, due not merely to improvement in operative technique and the employment of careful asepis, but especially to the employment in diagnosis of the X-rays and transillumination. Now, the surgeon can decide more effectively than ever before, the location, size and origin of the tumor he is about to deal with and is better able to select his cases.

Birch-Hirschfeld finds that of 214 cases of osseous tumor of the orbit described in literature 30 were external exostoses, 5 were hyperostoses and the remainder, 179, osteomata.

Of the exostoses 18 were operated on without a death; of the hyperostoses two operations and no death; of the oesteomata all sprung from one or more neighboring cavities. Of these the frontal sinus furnished 115, the ethmoid cells 52, the sphenoidal sinus 10 and the maxillary sinus 6.

The mortality in the cases not operated on was decidedly greater than when operation was resorted to. Comparing those cases reported since the introduction of antiseptics he finds in the frontal sinus osteomata operated on a mortality of 13.6 per cent. as opposed to 48.2 per cent. in those left to themselves; in the ethmoidal tumors operated on there was a mortality of 12.7 per cent.; not operated on 80 per cent. In the sphenoidal cases 33 per cent. died after operation; in those not interfered with 100 per cent.

The clinical histories and details of operation in two cases of osteoma of the orbit successfully removed by operation without involvement of the eyeball are given at length by Arnold Knapp (*Archives of Ophthalmology*, July, 1906, p. 353). In the first case the tumor was located attached by a small pedicle at the upper-inner angle of the orbit, displacing the eye downwards and outwards. After operation the wound was closed and healed by primary union. In the second case the mass occupied the upper half of the orbit, displacing the eye forward and downward on the cheek. It had a broad attachment to the entire upper bony wall. The origin of the growth was from the superior wall of the frontal sinus and it had penetrated the inferior wall and extended into the orbit. The wound was left open and a gauze drain inserted. Recovery was rapid and the wound closed in eleven days.

Extirpation of exostoses and osteomata. The prognosis in the growths will, as before stated, depend upon their size, situation and the locality from which they spring. It may be broadly declared that from the operative standpoint they belong to one of two classes. Either the tumor arises from and is attached to the anterior lamella of bone forming the orbital wall and in its future growth is confined to the orbit, or it is a growth from a neighboring cavity, presses against the orbital wall, pushes it towards the orbital axis and finally breaks through into the orbit itself.

Exostoses that spring from the inner table can generally be removed with the hammer and chisel at their attachment or a piece of bone including the point of union can be exsected.

Osteomata of the orbit, especially of the ivory variety, generally re-

quire additional means of enucleation. The electric (dentist's) drill, bone scissors, elevators, and saws may have to be called into play before these refractory growths can be entirely extirpated.

The subject of removing tumors of extraorbital origin comes naturally under other sections. It may here suffice to say regarding orbital tumors originating in the frontal sinus (constituting three-fourths of these growths) that Birch-Hirschfeld favors their total extirpation, when any operation is done, because his statistics show that the mortality in the first instance was only 8.9 per cent. as compared with 34.6 per cent. in the latter case.

Sub-aponeurotic orbitotomy. Under this title Rollet (*Actes du XII Congres Int. d'Ophtal.*, 1914) claims that his operation allows deep exploration of the orbit and often removal of orbital tumors, without injury to bone, nerves, blood-vessels, and orbital fat, with complete conservation of the integrity of the eye, and with an invisible cutaneous cicatrix.

After uniting the lids by stitches to protect the eye, a curved incision, not less than 3 cm. long, is made down to the bone at the outer margin of the orbit. The aponeurosis is separated from the orbital edge, and this opening admits to a space in which the finger can explore without injury to any orbital structure. It is bounded, on the one hand, by the orbital periosteum, and, on the other, by an aponeurosis which encloses the orbital fat, etc. In many cases the tumor is situated in this space.

External curvilinear orbitotomy. Genet (*Révue Gén. d'Ophtal.*, Feb. 28, 1913) gives this name to a procedure much like the foregoing operation devised by Rollet. He desribes the removal by it of a metastatic cancer of the orbit. The method consists in first stitching the lids together to prevent injury to the cornea, and then making an incision down to the bone along the outer edge of the orbit. When the aponeurosis has been divided, the orbit can be fully explored without injuring important structures. By thus keeping to the outer part of the orbit, one avoids injuring the levator palpebrarum, the superior oblique, the lachrymal sac, or the inferior oblique. The conjunctival sac is not opened, and it is not necessary to divide muscles in order to get room to work.

Fat transplantation in adherent cicatrices of the orbital margin. Verderame (Siena) (*Klin. Monatsbl. f. Augenheilk.*, Oct., 1909, review in *Ophthalmic Review*, p. 61, Feb., 1910), deals with the use of injections of paraffin for the removal of the unsightly appearance due to the presence of adherent cicatrices at the orbital margin, pointing out that this procedure cannot be considered free from danger since

there are on record cases in which pulmonary embolism, thrombosis of the ophthalmic vein, embolism of the central retinal artery, extravasation of paraffin into the eyelids, necrosis of the skin and other more or less serious accidents have resulted.

For the cases in question he advises us to fall back on the procedure recommended at an earlier period by Silex and Axenfeld, namely, the subcutaneous transplantation of fat at the site of the cicatrix.

A small incision is made through the healthy skin in the neighborhood of the cicatrix, after which, with the help of scissors, the attachments of the skin to the underlying bone are freely separated so as to allow the skin to be easily raised to its former level. A mass of adipose tissue of appropriate size is then taken from the subcutaneous tissue of the abdomen and inserted in the cavity and the wound carefully stitched.

Immediately after the operation there is some redness of the undermined skin, and a prominence in place of the original depression, and the parts gradually assume a more natural appearance and the cosmetic result is a good one.

Orbit, Osteoma of the. Bony tumors of the orbit are not so very rare.

In reporting a case of bony growth within the orbit H. F. Hansell (*Practical Med. Series*, Eye, p. 129, 1911) remarks that the origin of these neoplasms is usually in disease of the underlying bone or of that part of the wall of the orbit from which they spring. Bull believes that syphilis in the third stage is the cause in the majority of cases. An osteitis or periostitis is set up by syphilis, tuberculosis, malignant disease of the nostril or chronic nasal catarrh by which bone cells are deposited which proliferate or become heaped up to form an appreciable tumor. Since the ethmoid plate is the most frequent site of orbital osseous tumors, it is not improbable that nasal disease, not necessarily specific, is a common cause. Inflammation of the nasal mucuous membrane, concentrated in one or more foci, destroys the membrane and adjacent bone and a perforation allows access of the inflammatory process to the orbital periosteum. At the site of the perforation the membrane is elevated by inflammatory products and an aggregation of bone cells.

The signs of orbital tumor are not significant of the nature of the growth. They are exophthalmos, dislocation outward and downward of the ball, inaction of one or more muscles, ptosis, diplopia and occasionally optic neuritis. The diagnosis of a bony tumor may be made in those cases in which the growth is near enough to the anterior margin of the orbit to be palpable; however, but few cases are so favorably placed. Tumors arising from the ethmoid plate cannot

always be recognized as hard. They are covered by much soft tissue and the tactile sense may be deceived.

The location of the tumor in the orbit is rarely indicated by the degree of exophthalmos or by the loss of mobility. A slight increase in the contents of the orbital cavity, disarranging the relation between contents and capacity, may produce signs inconsistently great with the size of the tumor. For example, venous hyperemia of the orbit, accompanying Graves' disease, may be responsible for a high grade of exophthalmos. In the majority of cases of orbital tumor the ball is forced forward, downward and outward, independently of the sight of the growth, so that the position of the eye in the orbit or the line of its projection from the orbit is not a dependable indication of location. The degree of exophthalmos and of immobility does not bear a close relation to either the size or location of the tumor, but is more dependent upon the former than upon the latter.

Notwithstanding the usually unfavorable prognosis of operations for sarcoma of the orbit, and indeed the frequently expressed opinion that operation hastens recurrence and stimulates growth of the tumor, or whatever may remain of it after operation, to more rapid growth, the effort at removal seems to Hansell an imperative duty. If the tumor is malignant, enucleation, if it accomplishes any good at all, may relieve distressing symptoms, at least temporarily. If the tumor is not malignant, operation, particularly when the eyeball need not be sacrificed, may result in permanent cure.

The clinical histories and details of operation in two cases of osteoma of the orbit successfully removed by operation without involvement of the eyeball are given at length by Arnold Knapp (*Archives of Ophthalmology*, July, 1906). In the first case the tumor was located in the upper, inner angle of the orbit, displacing the eye downward and outward, and was attached by a small pedicle. After operation the wound was closed and healed by primary union. In the second case the mass occupied the upper half of the orbit, displacing the eye forward and downward on the cheek, and had a broad attachment to the entire upper bony wall. The origin of the growth was from the superior wall of the frontal sinus and it had penetrated the inferior wall and extended into the orbit. The wound was left open and a gauze drain inserted. Recovery was rapid and the wound closed in eleven days. (See, also, **Osteoma**.)

Orbit, Osteoperiostitis of the. See **Orbit, Abscess of the.**

Orbito-sus-palpébral. (F.) Levator palpebræ superioris.

Orbit, Periostitis of the. See **Orbit, Abscess of the.**

Orbit, Phlegmon of the. See **Orbit, Abscess of the.**

Orbit, Psammosarcoma of the. This rare new growth has been described by de Schweinitz (*Archives of Ophthal.,* 6. 469, 1914). The duration of the growth was two and one-half years. There was no history of trauma. The eyeball was pushed downward and outward, with no diplopia, loss of vision or fundus changes. Rotation of the eyeball was normal in all directions. Frontal and ethmoidal sinuses were not involved.

Operation, at the inner and upper margin of the orbit, revealed a large growth covered with a bony capsule. Removal of the bony covering was accompanied by escape of a small amount of clear fluid and the presence of a mass of tissue somewhat resembling brain tissue. Following the operation the eyeball returned to its normal position. There was diplopia at first, but it gradually subsided. Microscopic and chemical examination showed the presence of sarcoma cells and sand-bodies. There has been no recurrence of the growth.

Orbit, Rhabdomyoma of the. This new growth is excessively rare in the orbit. However, Jennings (*Am. Jour. of Ophthal.,* July, 1895), has described an instance in a child 14 months old. The tumor was congenital, loosely attached to the surrounding tissues, and on section was found to be composed of striated muscle fibres and connective tissue.

Orbit, Sarcoma of the. See, also, **Sarcoma.**

Frank Allport (*Ophthalmic Record,* July, 1912) describes the removal of a spindle-cell sarcoma from the right orbit followed by recovery with intact ocular apparatus. There were three tumors, all encapsulated; the capsule in each was removed unbroken. Artery forceps were not used, as the bleeding was not profuse, and was reasonably well controlled by adrenalin. The sides of the wound were held apart by long, smooth hand-retractors. One of the retractors also held the eye away from the field of operation. Patient dismissed in six days, at which time her vision was 20/15 and her fundus was normal.

H. Charlet (*Révue Générale d'Ophtal.,* Jan., 1912) reports briefly a case of optic atrophy associated with orbital sarcoma. The patient was 19, with failing sight. All symptoms of Bright's disease. Right eye showed temporal pallor of disc with difference in elevation of 2 D. between right and left side of papilla. O. S., normal. Diagnosis was primary optic atrophy, possibly of nephritic origin.

Six months later a very appreciable exophthalmus of O. D., pupil dilated. No reaction except consensually. No thrill. The cause attributed to an orbital sarcoma. Conditions cachectic. Rhinoscopy anterior showed tumor mass in the middle meatus. Transillumination negative. Surgical intervention refused. In six more months growth had invaded the nasal fossa, the pharynx and all the neighboring

tissues. Eye almost dislocated toward the left and immobile. The tumor was removed piecemeal at the time, patient dying from shock a few hours later.

Microscopically the mass was found to be a small round-cell sarcoma. The interesting features were: firstly, the latent period of about nine months during which the tumor produced only the optic atrophy, and, secondly, the subsequent rapidity of growth with accompanying symptoms.

In the presence of an atrophy indefinite in origin, it is always well to suspect an orbital tumor and have a thorough nasal examination made; and the only possibility of success in these cases lies in an immediate and thorough operation.

Zentmayer (*Ophthalmic Year-Book*, p. 328, 1913) has reported a woman of 74 years who in 1897 had been operated upon by Norris for an *encapsulated sarcoma* of the orbit, which had originated in the lachrymal gland. Further operations were done for recurrences in 1905, in 1910 (when the globe was enucleated and the orbit eviscerated), and in 1912, when the sarcoma had extended into the calvarium and there was a probably epitheliomatous growth below the inferior orbital margin.

In Van Duyse's case of *chondrosarcoma* of the orbit, the patient was a girl of 11 years, and the tumor was located between the orbital vault and the levator palpebræ. After five months a local recurrence was treated with radium emanations, and at the time of report eighteen months had elapsed without further recurrence.

Ide's case of *sarcoma* of the orbit occurred in a child less than a year old, who died a week after palliative enucleation, and less than a month after a fall on the right temple from which the parents distinctly reckoned the origin of the growth.

Orbit, Telangiectatic growth of. See **Orbit, Angioma of the.**

Orbit, Teratoid cysts of. See **Orbit, Dermoid cysts of the**; also **Congenital anomalies,** near the end of the section.

Orbit, Tuberculosis of the. Lebenhart (*Ophthalmic Year-Book*, p. 352, 1912) describes two cases of tuberculosis of the orbit, occurring in children of 3 and 4. In both, tuberculosis of the sphenoid and ethmoid sinuses was found. He calls attention to the ophthalmic signs: first, impairment of vision with subsequent atrophy; second, impairment and disappearance of light reflex; third, slight exophthalmos; fourth, absence of involvement of other orbital structures.

Orbit, Tumors of the. With few exceptions orbital tumors have been fully treated under such appropriate headings as **Orbit, Carcinoma of the.** Further complementary observations regarding these

growths as a whole will, however, be made here. The reader is also referred to the end of the section on **Congenital anomalies,** to the major heading, **Tumors of the eye,** and to such individual captions as **Sarcoma**; **Endothelioma**; **Osteoma**; **Lipoma**; **Angioma,** etc., where corresponding neoplasms of the orbit are described.

A good *account of orbital tumors in general* is given by De Obarrio (*Ophthalmoscope*, March, 1913). He points out that the contents of the orbit furnish such a variety of tissues that very few are not represented. A rigid, conical-shaped, bony container formed by seven cranial bones, lined by a continuous periosteum pierced by nine foramina or channels and lodging the lachrymal gland and adnexa, the ocular muscles, orbital fat, and cellular tissues, arteries, veins, nerves, lymphatics, a nerve of special sense, and the eye proper, any of which may give rise to neoplasms. In addition, we have metastases from other growths elsewhere, as well as invasions from adjacent cavities. It is easy, then, to foresee the great variety of simple tumors, as well as the perplexing number of compound neoplasms, that we may have to take into consideration in attempting a diagnosis.

General symptoms.—1. Exophthalmus. It is difficult to conceive of the existence of a new growth, seated in the orbit, without the presence of this symptom to some extent. 2. Impaired function. Motility will be diminished in the direction of the seat of the growth. Acuity of vision will be reduced, depending upon the volume of the neoplasm and its location, the symptom being more pronounced the more posterior the situation. 3. Presence of visible or palpable tumefaction.

Exophthalmus may be divided into the following varieties: (a) Vertical, comprising upward and downward displacements. (b) Horizontal, comprising inward and outward displacements. (c) Diagonal, comprising four varieties, upward and inward, upward and outward, downward and inward, and downward and outward. (d) Directly forwards.

Following this classification, it is fair to assume, for instance, that a forward displacement of the eye, with a slight upward and outward deviation, is an indication of a tumor of the optic nerve. Likewise, a downward displacement would indicate the presence of a growth at the vault or adjacent tissues; an upward displacement would have a similar significance as regards the lower wall of the orbit. An oblique displacement downward and inwards would be suggestive of a new growth of the lachrymal gland or adjacent bony wall, whilst a displacement downward and outward would be strongly suggestive of frontal sinus involvement in the shape of exostosis; for instance, an outward displacement should call attention to an affection of the

ethmoidal sinuses, and a similar reasoning should be properly applied to each one of the varieties enumerated above.

The means of investigation at our command are the history of the case, inspection, palpation, percussion, trans-illumination, focal lighting, fluoroscopy and skiagraphy, which should always be employed whenever possible. Another very useful aid is the aspirating needle, where there is the slightest indication of the presence of fluid.

Treatment. The surgical procedures are classified as follows: (a) Extirpation through soft parts with preservation of the eye. (b) Extirpation through a bony flap with conservation of the eye. (c) Extirpation with ocular enucleation. (d) Exenteration of the orbit which may be complete or subconjunctival or plastic.

Particular stress is laid upon the first method, extirpation through the soft parts, with preservation of the eye, which should obtain satisfactory results without resorting to more radical methods. However, thoroughness should not be sacrificed for conservatism.

The incision should preferably lie one or two centimeters from the orbital margin and parallel with it at the point of greatest protrusion, and comprise in one move the soft parts down to the bone. A careful dissection is necessary to a point of cleavage in all encapsulated tumors, and by following the same with a blunt instrument, extirpation will be greatly simplified. Inspection of the seat of the neoplasm by direct vision and digital palpation should be carefully made wherever practicable.

As has often been noted the *diagnosis between primary tumors of the orbit and orbital newgrowths* resulting from chronic inflammatory processes often presents considerable difficulty. Incorrect diagnosis may readily lead to sacrificing a hitherto useful or even normal eye, or at least to permanent interference with the normal mobility of the eye or of the upper lid. Miller of Vienna has studied a series of cases the histologic findings in which corrected the clinical errors of diagnosis, usually after surgical intervention had produced either loss of vision or disturbance of function. The majority of the cases date back to a period when the Wassermann test was not available, and although in most instances the new growth was probably or certainly of syphilitic origin, yet it would commonly have been impossible to establish such a diagnesis in any other way than by the therapeutic test. In one case, after operation had destroyed the sight of the first eye, the second eye became almost blind from optic neuritis, but recovered under mercurial inunctions. In one instance the trouble had started in a frontal sinusitis, the result being a bony swelling inside the upper rim of the orbit. In a recent case the Wassermann test was negative.

but the histologic appearance of an excised piece of tissue, together with the subsequent rapid recovery of the patient under mercury, left no practical doubt as to the luetic nature of the orbital growth. The tumors described had no characteristic in common, although the growth usually started from above. Usually there was no pain, or merely indefinite statements were made as to headache. In almost every case the periosteum was found involved at the time of operation. The tumors were as a rule not sharply limited.

Meller urges that before a serious operation is undertaken upon any orbital growth, every possible effort should be made to place its character beyond doubt, by tuberculin and Wassermann tests, examination

Exophthalmus and Proptosis of the Eye due to Non-malignant Inflammatory Hypertrophy and Hyperplasia of orbital Tissues. (Würdemann.)

of the nose and its accessory cavities, and finally, in every case in which syphilis can possibly be suspected, by vigorous treatment with mercury and iodin. When all these resources have been exhausted, an excised piece of the tumor should be histologicallly studied.

Orbituary. Of, or pertaining to, an orbit; orbital.

Orbit, Vascular tumors of. See **Orbit, Angioma of the.**

Orbit, Wounds of the. See **Orbit, Injuries of the.**

Ordeal nut. See **Physostigma.**

Ordinary image. One of the images produced by the double refraction (q. v.) of calcite and around which the *extraordinary image* (which see) rotates while the crystal is being turned.—(C. F. P.)

Ordinary ray. In *optics*, the ray which follows the ordinary law of refraction, as distinguished from the *extraordinary ray.*

In *doubly refracting crystals* the ray the path of which follows the law of refraction.

Organoleptic. Making an impression upon an organ, as the eye.

Organology of the eye. See **Comparative ophthalmology**; **Embryology of the eye**; **Histology of the eye**; as well **Anatomy of the eye**; and under the various individual captions, covering separate ophthalmic organs.

Organotherapy. Of the animal extracts recommended as therapeutic agents during the past few years we are mostly interested in those from the adrenal glands, described under **Vaso-constrictors** (q. v.), from the thymus gland, the liquid extract ($\frac{1}{2}$ to 2 fld. drachms) and dessicated powder 3 to 5 gr. of which have been given thrice daily with some success in exophthalmic goitre (q. v.), and from the testes and retina.

Didymine, or testicular substance, marketed by Burroughs, Welcome & Co., in 5 grain tablets has been prescribed with effect in Basedow's disease and by Dor for asthenopia in children where accompanied by unduly rapid growth.

Optocine, from the retinæ of freshly killed animals, is so prepared that one fluid ounce contains the activities of four retinæ.

R. W. Doyne [extracts from various portions of the ocular apparatus have also been employed in ocular therapy by Dor (1897), Lagrange (1898) and Darier (1900)] first introduced this product and advised its use in the treatment of retinal affections, including tobacco amblyopia, retinitis pigmentosa, and myopic choroiditis.

Orgelet. Orgeolet. (F.) Hordeolum; a style.

Oribasius. A famous Pergamene physician, who became the body-physician to Julian the Apostate. Born at Pergamos 326 A. D., he studied in Alexandria, and settled as physician in Athens. While here he received his appointment to Julian, who afterwards became emperor. The physician accompanied his ruler on the expedition into Gaul, and, later, into Persia. After the death of Julian, Oribasius was so mistreated by Valentinianus and Valen (the successor of Julian) that he fled to the Barbarian Goths. Here his reputation as a doctor became so great that he was recalled to Byzantium, restored to his former honors, and given back his property. He died in 403.

His writings were as follows:

1. *Medical Collections.* Prepared by request of the Emperor Julian. (This consists of a compilation from the writings of all the Greek physicians of any consequence, beginning with Hippocrates. Every

extract in the book, moreover, has attached thereto the name of the author from whose writings it was extracted.)

2. *The Synopsis.* This is merely a synopsis of the more important passages in the "*Medical Collections,*" made for the benefit of his son, Eustathius.

3. *On Household Remedies.* This work was dedicated to the author's friend, Eunapius, and the educated laity.

All these works contain ophthalmologic passages which (though none, as a matter of course, is original with Oribasius) are still of great importance as completing our knowledge of some of the numerous authors from whom the passages are taken.—(T. H. S.)

Orient. Orientate. (a) To ascertain or determine the position of a body with respect to the points of the compass. (b) To turn towards the east.

Orientation, Visual. The act of taking bearings with respect to the points of the compass, or of ascertaining direction in general, chiefly by the employment of the sight sense.

F. R. Yelland (*Lancet*, June 24, 1916) showed a patient with loss of visual orientation, following a wound four months previously. Soon after being put to bed he had a genuine epileptic seizure and was inaccessible for 14 hours. He afterwards presented right hemiplegia, which cleared up later, but he had erroneous visual projection. The condition was improving. Leslie Paton, discussing the foregoing case, drew attention to a similar case under the care of Captain S. Smith and Colonel Gordon Holmes (*Brit. Med. Jour.*, March 25, 1916). He narrated the results of the tests he had carried out with the present patient. He had satisfied himself that the faulty projection was not due to defective eye movements. He believed that there had been complete destruction of the right occipital cortex, the left visual sensory cortex having escaped very well. There seemed to have been a complete severance of the superior longitudinal commissural fibres.

Emphasis has been laid by Trowbridge on the importance of lateral vision in its relation to orientation. Man has but a poor apparent displacement of objects at the side, because of the forward position of the eyes when at rest. Birds, however, have the advantage of man in that respect, in that the lateral position of their eyes allows them excellent peripheral vision. But at rest, such creatures have no means of judging distance of surrounding objects except by comparison of size. In man, however, the lateral vision is important because of the imparted sense of direction.

Origanum. Common marjoram. Wild marjoram. Herb of *Origanum vulgare.* About the only relation of this plant to ophthalmology lies

in the fact that it is employed in the manufacture of absinthe, and may be responsible for some of the toxic symptoms of that poisonous beverage. See Vol. 1, p. 40, of this *Encyclopedia.*

Orobechos. OROBECHUS. (L.) (Obs.) A crackling sound, like the snapping of a pod, sometimes observed in the inner angle of the eye on hard pressure by the finger—probably due to pressing upon a dilated lachrymal sac.

Orsudan. A proprietary arsenical preparation (sodium—3—methyl—4—acetyl-amino-phenylarsonate). It is given in syphilis and other protozoan diseases, generally by intramuscular injection; dose 10 grs. (or 0.6 grm.).

Ernest Clarke (*Ophthalmic Review*, p. 223, July, 1910) relates instances of advanced optic atrophy following the use of orsudan and soamin in the treatment of syphilis. The first case was a man, aged 46, who was first seen in October, 1908, and had become infected in August of the same year. After ten injections of soamin gr. v, the sight began to fail; and in February, 1909, he had five more injections, when the sight again failed after the third. At the end of 1909 he had some mercury injections, and at the time of the report his vision was found to be only hand movements in the right eye, and 6/12 pt. in the other: while both discs showed optic atrophy of the primary type; the vessels were normal, and there was no other change.

The other case was a man, aged 49, who came under observation in October, 1909, having become infected in August. After receiving nine injections of orsudan his sight began to fail, and the vision in both eyes had become reduced to counting fingers. Both discs showed primary atrophy, and the vessels were practically normal; in addition there were degenerative changes in both maculæ.

Clarke alluded to similar cases already described by others—viz., by Major Ward, Bagshaw, van Someren, and Leudie and Blaikie; and mentioned that soamin was a sodium para-amido-phenyl arsonate, and orsudan was a sodium tri-methyl tetra-acetyl amido-phenyl arsonate. It was probable that these drugs acted by producing degeneration of the ganglion cells of the retina, or possibly a secondary atrophy of a retrobulbar type. The writer urged greater caution in the use of these drugs, and careful attention to the general health before employing them.

Ortho-. A prefix meaning straight or normal.

Orthochromatic. Normally colored or stained; rendering colors in correct relationship as to their intensities.

Orthochromatise. To bring into conformity with the conditions requisite to obtain a correct rendering of color-values.

Orthoclastic. ORTHOTOMOUS. Cleavage of a crystal in two directions, at right angles to one another.

Orthodiagraphic transilluminator. ORTHODIAGRAPH. A radiographic apparatus for recording with accuracy the proper size and form of organs and tissues within the body, without the distortion resulting from the use of the ordinary X-ray plate. Duken (*Ophthalmic Year-Book*, p. 349, 1916) observes that just as in general surgery orthodiagraphic transillumination is the best method known, so it is also for the determination of foreign bodies in the eye. This writer considers it far superior to the plate with lead glass prothesis or stereoscopic plates. In orthodiagraphic transillumination, the globe itself can be made directly visible and the movements of the eye studied in all directions. False projection falls away, as one is operating with centered rays. Even the smallest sliver can be seen and localized.

Orthoform. This agent is a white, colorless, crystalline powder, slightly soluble in water, more so in alcohol and ether. Orthoform is a complicated chemical organic compound with anesthetic, anodyne and antiseptic qualities. One of its ophthalmic uses is as a 10 per cent. mixture with starch in burns of the face and eyelids.

The *Bulletin Générale de Therapeutique* gives the following formula for making modified copper sulphate pencils for trachoma and other forms of granular lids into which orthoform also enters: Cupri sulph. pulv., 10.00; orthoform., 5.00; holocain hydrochlor., tragacanth.,āā 4.0; aquæ dest. q. s.

Mix thoroughly and roll into pencils of convenient size.

Orthogon. A rectangular figure.

Orthographic. Pertaining to right lines or angles.

Orthometer. EXOPHTHALMOMETER. An instrument devised by von Hasner for determining the degree of protrusion of the eyes. It consists of two parallel square frames, 43 mm. apart, similarly divided by horizontal and vertical horse-hairs, 8 mm. apart. Over the corresponding threads are sighted the points by means of which it can be determined how much one eye projects beyond the other.

Ortho-oxybenzoic acid. See **Salicylic acid,** p. 72, Vol. I of this *Encyclopedia.*

Orthoptic. Correcting obliquity of one or both visual axes.

Orthophenolsulphonic acid. See **Aseptol.**

Orthophoria. EUPHORIA (Stevens). EUKINESIS (Howe). The oculomuscular state in which the visual axes tend to remain parallel when the eyes are adjusted for distance, and to converge properly upon the point of fixation for other distances. See **Muscles, Ocular.**

Orthoptic. 1. Correcting the obliquity of one or both oblique axes.

Orthoptic exercises, the use of the amblyoscope, stereoscope and similar instruments for the purpose of straightening a strabismic eye.

2. A small stop, i. e., an opaque screen having a small hole pierced in it, used by riflemen and others in taking sights.

Orthorhombic. Rectangular and rhombic.

Orthoscope. An apparatus which neutralizes the corneal refraction by means of a layer of water: it is used in examining the eye. See **Hydrophthalmoscope**, p. 6085, Vol. VIII; also on p. 4752, Vol. VI of this *Encyclopedia*.

It is also the name given to a patented British instrument, one of the several combined retinoscopes and ophthalmoscopes on the market. The fundus view is confined to the indirect image.

Orthoscopic. Giving a correct undistorted field of vision.

Orthoscopic image. In *optics*, an image that is free from distortion (measured by the aberration), and which, therefore, is exactly *similar* to the object in its entire extent; in other words, an image which is "angle-true." See also **Image**.—(C. F. P.)

Orthoscopic lens. A lens that produces an orthoscopic image.

Orthoscopic ocular. An ocular specially designed to give a large, flat field.

Orthoscopic points. In *optics*, the centers of the entrance and exit-pupils specifically when they fulfill the requirements of (1) spherical correction of the stop-center with respect to the object- and image-space of an optical system, called by von Rohr the Bow-Sutton condition, and (2) Airy's tangent condition, in which the ratio between the slope-angles of every pair of conjugate chief-rays is a constant. In other words, when the pupil centers are free from aberration, they are called *orthoscopic points*.—(C. F. P.)

Orthoscopic spectacles. Spectacles, the lenses of which are cut out of the periphery of a large lens.

Orthoscopy. In an optical system, that condition in which all pairs of conjugate chief rays trace similar figures on the object-plane and image-plane. See also **Orthoscopic points**.

Orthosulphamin benzoate. See **Sodium benzosulphinide**.

Orthosulphocarbolic acid. See **Aseptol**.

Orthotomic system of rays. In *optics*, a system of rays for which a surface can be constructed which will cut all of the rays at right angles. See, also, **Law of Malus**, p. 7024, Vol. IX of this *Encyclopedia*.—(C. F. P.)

Ortive. Relative to the rising of a star.

Ortoforia. (It.) Orthophoria.

Os. (F.) Bone.

Oscillating field. Variations in the extent of the visual field, particularly characteristic of hysteria. See p. 299, Vol. I, and p. 6123, Vol. VIII of this *Encyclopedia.*

Oscillating pupil. See **Hippus,** p. 5940, Vol. VIII of this *Encyclopedia;* also the major heading, **Pupil in health and disease.**

Oscillative. Having a tendency to oscillate; vibratory.

Oscilloscope. An attachment used in series with an X-ray tube, by which the presence of inverse rays may be detected. See **Electricity.**

Ose. A loop at the end of a platinum wire inserted into a glass handle, used chiefly for the collection of bacterial fluids and semifluids for microscopical examination.

Osio, Dr., of Madrid. Born at Caracas, in Oct., 1840, he received his medical degree in 1865. He then studied ophthalmology with Michel, Desmarres, Wecker and Galezowski, in Paris; with Critchett, in London; with Graefe and Hirschberg, in Berlin; with Magnus, in Breslau; and with Arlt and Fuchs in Vienna. In 1869 he settled as ophthalmologist in Barcelona, Spain. Here he lectured on ophthalmology till 1881, when he removed to Madrid. Here he died July 21, 1900.

His most important ophthalmologic writing is "*L'Oftalmia Purulenta del Recien Nascido*" (a useful work of popular character; Madrid, 1886). He also translated von Mooren's work, with the title "*Relacion Entre Padecimientos Uterinos y las Afeciones de los Ojos*" (Madrid, 1884). He was one of the founders of the "*Revista de Ciencias Medicas.*"—(T. H. S.)

Osmosine. See **Cadmium sulphate,** p. 1354, Vol. II of this *Encyclopedia.*

Osmosis. The transudation of fluids through a porous septum. If two fluids of different constitution and character are separated by a more or less porous organic membrane, each passes slowly through it and intermingles with the other. See **Circulation of the intraocular fluids,** p. 2257 of this *Encyclopedia.*

Osseous cataract. The connective tissue growing into the exudate of adherent cataract (q. v.) from the ciliary body may invade the capsular sac and there suffer further changes and even lead to the formation of bone in the region of the lens, or within its capsule.

Ossiculum hamuli. A term applied by Macalister to a separate horny nodule in the trochlea near the anterior border of the lachrymal groove.

Ossification of the eye. The formation of true bone in the eyeball is generally the final stage of a degenerative process, and is usually discovered several years after the eye has been blind. The principal example of bony formation in the human has already been discussed under **Bone in the choroid,** on p. 1245, Vol. II of this *Encyclopedia.*

Other ossifying processes are referred to under various captions,

but the best review of the subject is the abstract of a paper of L. Bussy *(Les Processus d'Ossification dans l'Œil Pathologique)* by Sydney Stephenson (*Ophthalmoscope*, p. 251, April, 1914) Bussey says that in the human eye ossifications have been described, of which the origin, site, nature and evolution differ.

Those having a teratological origin and which result from an anomaly in the phenomena which preside over the constitution of the crystalline lens and the optic cup are very rare. They take the form of small benignant tumors under the conjunctiva, osteomata of the conjunctiva.

Others, rarer still, are also situated under the conjunctiva, but they are of inflammatory origin, and their chief cause is trachoma. They represent the transformation of newly-formed connective tissue into bone. They are accompanied by hyaline or amyloid degeneration, and are spoken of as instances of ossifying conjunctivitis.

As regards the choroid, osteo-sarcomata have been described, but the cases which have served to create this type of intra-ocular ossification may be interpreted in another way. They are usually connected with old inflammatory ossifications upon which a sarcoma has been grafted. There are inflammatory ossifications of the choroid, secondarily complicated with sarcoma; but it does not appear that we are authorized in describing an osteo-sarcoma of the choroid.

We very frequently encounter inflammatory osseous new formations inside atrophied stumps. They represent the ultimate transformation of inflammatory exudations produced in the membranes and the media of the eye by infections. These exudations at first became organized into vascular fibrous tissue. Certain cells of the exudation, themselves arising from the lymphocytes, become differentiated into osteoblasts, secrete osseine, and make a primordial bone, which when revascularized, gives rise in its turn to definitive Haversian bone. Since the exudations may be produced in any part of the eye, ossification may be met with in all the membranes and in all the media of that organ. Very rare in the iris, the cornea, and the retina, they are commoner in the vitreous and the crystalline and more numerous still in the choroid, which is indeed their seat of predilection.

All that has been said regarding intraocular inflammatory ossification applies also to intraocular inflammatory enchondromatosis, except that the latter is as rare as the former is frequent.

The etiology of the inflammatory ossifications is to be sought in an infection produced by a penetrating wound of the eyeball, by a spontaneous ulceration, or by a metastasis. New formations of bone may appear soon after the causal infection. They may become larger until

they attain such dimensions that surgical intervention is necessary, or they may rest stationary, or even in some cases undergo absorption.

They constitute a very grave and constant menace, and may, in fact, be regarded as a frequent cause of sympathetic ophthalmia.

In the absence of really pathognomonic signs, radiography is the most certain means of diagnosing the condition.

An eye which contains bone is always useless, often troublesome and painful, and sometimes dangerous. Treatment may be summed up in the words "prompt enucleation."

Experiments (choroidal graft) show that the eye is a favorable medium for the development of osseous tissue. It does not nourish the grafts (greffons), but, on the contrary, absorbs them. In the midst of the young connective tissue which is substituted for the resorbed graft the choroid forms new bony deposits.

While placing ourselves in conditions analogous to those which entail the production of ossification of the eye in man, we have not obtained the formation of osseous tissue in animals.

Osteitis. Inflammation of bone.

Osteitis deformans. Paget's disease.* See, also, **Leontiasis ossea,** p. 7420, Vol. X of this *Encyclopedia.*

Osteochondroma. A new growth consisting of both cartilaginous and bony structures. It rarely affects the ocular tissues but lachrymal gland tumors are known.

Osteoma. Exostosis. A reference to this bony growth is made on page 4875, Vol. VII of this *Encyclopedia.* It is confined in the eye to the conjunctiva, lachrynal gland, eyelids and orbital walls. See **Orbit, Osteoma of the**; as well as **Conjunctiva, Osteoma of the,** p. 3048, Vol. IV of this *Encyclopedia.*

Osteoma of the eyelids is exceedingly rare. Sbrana (*Bollettino d'Oculistica*, Vol. 24, p. 177) describes a congenital example in the upper lid of an Arab, aged 44. M. Greco (*Archivio di Ottalmologia*, p. 606, 1915) reports an *osteo-angioma of the lid.*

According to the patient, a man of 45 years, the condition had been present since he was 6 years old, having appeared after attacks of vomiting. The region of the right lower lid and lachrymal sac presented a swelling of the size of half a mandarin orange, more prominent at the nasal end. Its upper border was distant 0.5 cm. from the free margin of the lid. The mass was composed of two distinct parts. The rounded nasal portion was bone hard, and of the size of a filbert. The outer portion, two-thirds of the whole mass, was completely independent of, but closely applied to the outer aspect of the bony growth, and had a soft but not fluctuating consistency. Beneath

the soft mass the lower orbital margin was perfectly regular throughout. On account of a discoloration of the skin and of the presence of venous arborization along the skin of the lower lid, the author diagnosed the simultaneous presence of an angio-lipoma and an osteoma.

In a recent review of *orbital osteoma* (*Ophthalmology*, p. 212, April, 1916) an abstract is given of the case of E. M. Blake (*Ophthalmic Record*, Aug., 1913) who described a patient, a man, 82 years of age, with an extensive osteoma due to the entrance of a particle of sawdust into the left eye about sixty years previously! X-ray photographs showed the tumor to be an osteoma of the frontal bone extending back into the apex of the orbit and apparently invading the frontal sinus. Thick offensive pus was discharged from incisions made into the growth with the object of relieving pain. Further operative treatment was not deemed advisable.

Wray (*Trans. Oph. Soc. U. K.*, p. 190, 1915) deals with the diagnosis and treatment of osteoma of the orbit.

He says that most of the bony growths met with in ophthalmic work are orbital, or, to be more exact, originate from the sinuses, although a few arise from the periosteum of the margin of the orbit. Their diagnosis may be simple or exactly the reverse. The orbit (the depth of which is about 50 mm.) may be explored with the finger, the probe, or the spatula, but before any of these special examinations are made, morphine should be given and deep injections of novocaine be made. In order to be used with safety, the end of a probe should be blunt, and the probe should be bent to the shape of a squint hook. The spatula should be of flexible metal, 10 mm. wide, with the extremities 2 mm. thick. From figures obtained from the cadaver, Wray finds that the spatula when pressed into the skin can be passed to a depth of 15 mm. above, of 12 mm. below, of 15 mm. on the inner side, and of 11 mm. on the outer side of the orbit. If the spatula be passed per the conjunctival fornices, the measurements are:—above, 33 mm.; below, 16 mm.; inner side, 21 mm.; and outer side, 22 mm.

The Röntgen rays should be employed in the diagnosis, particularly in the osteomatous growth, and in every case sagittal and profile negatives should be obtained. The "posing" of the patient in accordance with the position of the growth, as suggested by the direction of the exophthalmos, which is done for the purpose of avoiding shadows, is of considerable importance, although Wray is constrained to admit that a careful examination of the results obtained with the X-rays is, upon the whole, somewhat disappointing. It is still necessary therefore to depend mainly upon old established lines of clinical examination.

Wray is of opinion that operation should be undertaken even when

dealing with slowly growing osteomata, and justifies his position by the mortality figures of Birch-Hirschfeld, quoted below:

MORTALITY IN CASES OF OSTEOMA OF THE SINUSES

	Unoperated.	Operated.
Frontal	48·2 per cent.	13·6 per cent.
Ethmoid	80·0 per cent.	12·7 per cent.
Sphenoid	100·0 per cent.	33·0 per cent.

The mortality would doubtless be still lower than that given by Birch-Hirschfeld if operation were undertaken whilst the growths were small and the sinuses but slightly distended.

The difficulties of removal depend upon the size and hardness of the growth and the nature and extent of its attachment. One rule applies to all operations for osteomata of the orbit, namely, that any existing membrane and the periosteum should be most carefully preserved unbuttonholed, so as to shut off the field of operation from the tissues of the orbit. By means of a drill or gouge, it is then ascertained whether one has to deal with a cancellous or an ivory growth. In the case of the cancellous growth, slight leverage is employed, in the hope that it may be attached by means of a narrow pedicle. In the contrary event, the growth must be removed by means of a small saw, or cut away piecemeal by the aid of bone forceps, until its site of origin is exposed or its involvement of a sinus made clear. It may be possible to remove the sinus portion through the aperture in the orbital wall, but if this be not so, part of the orbital wall must be taken away, after which the removal of the growth will probably offer no particular difficulty. In dealing with the ivory osteoma the principles of surgical treatment are essentially the same. After removal of the growth, blood-clot should be removed, the edges of the periosteum be sutured, leaving a small aperture for a drainage tube. Finally, the edges of the skin incision should be brought together, and the parts dressed in the usual way. After-treatment is simplified by the fact that sepsis rarely complicates osteoma of the sinuses. The dura mater may be exposed, but if technique be correct, the danger does not appear to be at all great.

Osteopathy. This is a system of healing which regards manual therapeutics (especially massage) as the proper method for stimulating remedial forces within the body, "correcting misplaced tissue and removing interferences with the fluids of the body." It is based on the theory that "many diseases, especially those of the vertebral

column, arise from bony lesions and affect the nervous system and the circulation of the blood." First advocated by Dr. Andrew T. Still (1874), it is now used for the treatment of both acute and chronic conditions. The cult has six colleges in which all the subjects of the medical curriculum, except materia medica, are taught. The practice is regulated (1914) by law in thirty-five states. There are at present about 4,000 osteopath practitioners, mostly in the United States and Canada. See Still, *Philosophy and Mechanical Principles of Osteology;* and Teal, *Practice of Osteopathy;* also *Osteopathic Treatment of Diseases of the Eye, Ear, Nose and Throat*, by J. Deason, Chicago.

Osteoporosis. Brittle bones. Abnormal porosity of bone, with enlargement of its canals and the formation of pathologic interspaces. See **Blue sclerotics,** p. 1237, Vol. II of this *Encyclopedia.*

Osteo-sarcoma. A sarcoma attacking bone or a sarcoma partly made up of osseous tissue. Occasionally these compound new growths are found in the orbital walls.

Otemplastrum. An old term for a plaster to be put behind the ears for the relief of eye troubles.

Othalmomacroscopy. A term applied by Casey Wood to a naked eye study of the ocular tissues—especially of the fundus—in prepared specimens.

Otheoscope. A Crookes' radiometer.

Other Fabricius, The. One of the first to apply a magnet in ophthalmology. See **Fabry, Wilhelm.**

Othonna. An Arabian plant, no longer identifiable, whose juice was employed in ancient Greco-Roman times as a certain remedy for any and every affection of the cornea.—(T. H. S.)

Otitis media. See **Otology and ophthalmology.**

Otology and ophthalmology. The relations of the eye and ear have already been discussed under such captions as **Ear and eye,** p. 4114, Vol. VI; under **Choked disc**; **Meningitis**; as well as under **Deafness, Ocular relations of,** on p. 3782, Vol. V of this *Encyclopedia.* In addition to the material to be found under these headings one may recall the belief of Gruening (*Archives of Ophthalm.*, p. 153, 1913) that in acute purulent meningitis due to otitic causes there is a true inflammation of the optic nerve. Though there may be an increase of intracranial pressure there is no choked disc, because early in the disease the intervaginal space is sealed by exudative material. The choking of the disc in purulent middle-ear affections may be due to a diffusion of the pyogenic toxins producing a change in the walls of the distant vessels allowing a transudation of the serum of the blood.

In Tweedie's review (*Ophthalmic Review*, p. 16, Jan., 1910) of the exhaustive paper by Park Lewis (*Annals of Ophthalmology*, Jan., 1909) the writer states that the object of his essay is: 1st. To call attention to the fact that clinical evidence shows that such relationships exist between the eye and the ear that an irritation or improper functioning of the former may be manifested in a disturbance of some character in the latter. 2nd. To show anatomically what these relationships are. 3rd. To show that a complex of symptoms closely resembling those of Ménière's disease may be produced through incoordinate action of the eyes; and 4th. This is of especial importance to show that in the physiology of vision the cerebellum exercises governing functions.

By way of demonstration of his thesis he first instances various cases in which correction of refractive errors led to cures of "tinnitus aurium," "repeated and increasing attacks of dizziness," "sensation of burning with a feeling as of wind in the ear" and "vertigo."

The cure of tinnitus aurium accords with an instance in the reviewer's own experience, in which this symptom was relieved entirely, though only for a few days, after the patient had adopted the use of appropriate glasses, and which undoubtedly appeared as a case of "propter hoc." It occurred in a case of otosclerosis, the condition of aural disease with which tinnitus is perhaps par excellence associated, and for this most intractable and unresponsive disorder any methods of treatment or suggestions as to alleviation will be universally welcomed. The avoidance of all overstrain and worry and the removal of any incidental disability as far as possible has been the generally recognized form of treatment in these cases and the suggestion that one should insist on the correction, in addition, of even the smallest errors of refraction accurately corresponds with the advice usually given to sufferers in this respect. It will be interesting to note the effects and watch further reports of the treatment of tinnitus carried out in his direction, and though one cannot expect the associated deafness to be appreciably affected thereby, it is of the distressing "noises" that those afflicted with otosclerosis almost always chiefly complain.

Marcel Rollet arrived, in a paper read before the *Société Française d'Oto-Rhino-Laryngologie*, at about the same conclusions as Lewis. He said that there exist between the organs of vision and those of audition certain relations—both direct and indirect—relations which the nervous connections, both central and peripheral, of the two organs suffice to explain, and it must be admitted that in the case of objects which may be recognized by the two organs the excitation of the one of them may awaken through the association fibres the images of the memory belonging to the other organ.

Ocular-motor paralysis of otitic origin. It is with the second or basilar division of the oculomotor nerves that otogenic lesions are intimately concerned, and it is also in this portion that rhinogenic diseases affect the nerve trunk. It is necessary that some account be taken of the latter, as well as the concomitant affection of the other oculo-orbital nerve trunks, in order to discuss the differential diagnosis of paralysis induced by disease of the auditory organ in the temporal bone from that originating in neighboring parts. The number of otogenic and rhinogenic lesions of the oculo-orbital nerves which have been published is small, but of these the latter are numerous and the former rare.

In describing the anatomic relationships of the oculo-orbital nerves to the temporal bone F. H. Westmacott (*Lancet*, Nov. 14, 1914) says that all the nerves are situated near the apex of the petrous portion, and well out of the way of disease limited to the organ of hearing, but extension of disease by bone or soft parts have different results. The oculo-motor nerve is relative to the temporal bone, in the extra-dural portion, and it is continued through the external wall of the cavernous sinus, being separated from it posteriorly by a thin membrane, while in front it lies in the blood-stream. It is, however, the most distal relation of the oculo-orbital nerves, from its superior position in the sinus. It is in this situation that it gets communicating fibers from the sympathetic plexus surrounding the internal carotid artery, which passes upwards at the apex of the petrous bone, close to the third nerve in the cavernous sinus. It also receives sensory fibers from the ophthalmic division of the fifth nerve.

Paralysis of all the muscles supplied by the oculo-motor nerve, without other muscles being implicated, is caused by a nerve lesion before its entrance to the cavernous sinus, a distance varying from two to three centimeters, and it is usually in this position that disease of the auditory apparatus and temporal bone attacks the nerve by continuity. In the cavernous sinus it is possible that the fifth, fourth, and possibly the sixth nerves will be affected, according to whether the pressure is from within the cavernous sinus (due to thrombosis or aneurism of the carotid artery) or whether the pressure is on the external sinus wall. Disease of the sphenoidal cells is frequently in casual relationship with this manifestation, since the cavernous sinus and its contents are in close contact with the outer wall of the sphenoidal cavity in varying degrees, as described by Onodi. In the superior orbital fissure the nerve lesion would be accompanied by damage to the other oculo-orbital nerves. In both situations there would be unilateral, total ophthalmoplegia. If, however, a lesion affects all the nuclei of the oculo-motor

nerve, there will be two additional factors—first, the cross fibers passing to the other eye are affected; and, second, the fibers arising from the seventh nucleus to the orbicularis oculi, close to the origin of the fibers of the levator palpebræ, being attacked cause paralysis of the orbicularis and absence of the usual symptom in complete oculo-motor paralysis, that of the raised eyebrow on the affected side. A further point of importance would be the presence of abducens paresis or paralysis of the opposite side (associated fibers). Slight affection of the lateral rectus and superior oblique is sometimes observed in total paralysis of the third nerve, demonstrated by the field of fixation limitation in the lateral and infero-lateral part.

Otoscope. An ear speculum.

Ottalmodinamometro. (It.) Ophthalmodynamometer.

Ottalmoscopia. (It.) Ophthalmoscopy.

Ottico. (It.) Optic.

O.U. An abbreviation for *oculus uterque*, each eye.

Ouabain. This agent is obtained in both a crystalline and amorphous (glucoside) form from the poisonous *Acocanthera*. There seem to be relations between it and some of the strophanthins. Both ouabain forms have the power of producing complete corneal anesthesia *in animals* after four to eight minutes on the addition of one to a thousand solution, drop by drop. The anesthesia may remain for one to three hours, and gradually disappears. Symptoms of irritation appear but are not marked. The pupils contract and the intraocular pressure is raised. Crystalline ouabain calls forth no local anesthesia in the eye of man.

Ourari. Curare.

Outer canthus. The outer commissure of the lids.

Outlook for the Blind. The name of one of the best known American periodicals devoted to the interests of the blind. See **Institutions for the blind**, p. 6525, Vol. IX, of this *Encyclopedia*.

Outscooping. Removal of a substance from a cavity by means of a scoop (said especially of cataract).

Ouverture de l'objectif. (F.) Lens aperture.

Oval. Resembling an ellipse.

Ovalescent. Tending to an oval form.

Ovaliform. Oviform. Egg-shaped; having the longitudinal section oval and the transverse circular.

Ovaloid. Somewhat oval.

Ovarian diseases, Ocular symptoms in. As indicated at the end of this section the subject is to some extent treated in other volumes. Probably, however, the most important article in the literature is that of

Galezowski and Berche (*Recueil d'Ophtalmologie*, April, 1911; reviewed in the *Ophthalmic Review* for Oct., 1911).

Ocular troubles associated with the menopause, these writers point out, have been frequently noted, such as hemorrhages, chronic inflammation of the uveal tract, episcleritis, optic atrophy, and glaucoma. The scantiness of records of cases of ocular affection after the artificial menopause may perhaps be accounted for by the comparative rarity of the cause; moreover, the few published cases of this nature include none of inflammation of the uveal tract; nor have the authors seen cases of chronic uveitis after the menopause. These cases all present a somewhat similar clinical course; the first symptom is a slight dimness of vision, which is found to be due to a deposit of dots on the back of the cornea with little or no inflammatory signs; then appear sub-inflammatory attacks of short duration and at intervals corresponding with these at which the menstrual periods used to occur; posterior synechiæ develop, clouds appear in the vitreous, and the case gradually progresses to atrophy of the globe.

The authors' object in this paper is to publish several cases in which similar symptoms followed ovarian castration, together with the results of treatment.

In the first case a single woman of 29, in fairly good general health, and with no rheumatic history, presented, first in one eye and six months later in the other, diffuse vitreous haze with very little external signs of inflammation and no deposit on the cornea. She had a double salpingitis, probably of gonorrheal origin, but no history of syphilis. She was treated by mercury and iodide fully, without any effect. There were no obvious signs of tubercle.

In July, 1910, she entered another hospital, for removal of the ovaries. In September she returned with great aggravation of the ocular symptoms; there was now intense injection of both eyes, much deposit on the corneæ, posterior synechiæ and opacity of vitreous; V. $^6/_{60}$ in each. She was ordered capsules of ovarian extract, half a gramme daily, for three weeks. At the end of this time there was great amelioration in this condition of the eyes; V. $^6/_{36}$. The same treatment being continued for two months there was progressive clearing up of the inflammatory symptoms, and the vision reached $^6/_9$ in one eye and $^6/_{12}$ in the other, the corneæ being clear of deposit. The ovarian extract was now stopped. Three months later the patient returned with the eyes again acutely inflamed. The treatment was resumed, with a similar result, so that the end of of March, 1911, vision in one eye was $^6/_6$ and in the other $^6/_9$.

The authors do not look on the gonorrheal infection as having any

direct relation to the inflammation of the eyes in this case. The extremely torpid uveitis of the earlier stage was, they consider, due to a mild degree of hypo-ovarianism; a condition which was developed in its full intensity by the subsequent removal of the ovaries.

Their second case is more convincing in that the complication of a possible infection was absent, the case being one of simple metrorrhagia for which the ovaries were removed at the age of 29. She suffered from the usual troubles of the artificial menopause and in addition, about 6 months after the operation, began to have recurrent attacks of inflammation of the eyes, each attack lasting 3 or 4 days to a week, and the intervals being similar to those of her former periods. She was seen when these attacks had been going on for four years: the eyes were painful, with much pericorneal congestion, deposit on the corneæ and vitreous opacity. In this case, as in the first, specific treatment was first tried without effect (Wassermann reaction negative), and ovarian extract was then given with a result almost precisely similar to that in the first case.

The foregoing suggests a trial of opo-therapy in those cases of low-grade progressive irido-cyclitis in women past the menopause which are so unresponsive to treatment on the ordinary lines; although the authors warn us that we must not expect in the natural menopause results as definite and striking as in the cases due to surgical removal of the ovaries in younger women. See, also, **Climacteric**; and **Menopause.**

Ovate. Having a figure similar to the longitudinal section of a hen's egg; oval, but broader at one end than at the other.

Ovate-oblong. Between ovate and oblong.

Over-corrected. A term applied to lenses in which the central rays are focused sooner than the marginal rays.

Over-exposure. Exposure of the sensitive plate for a period longer than is necessary to produce a perfect picture.

Over-ripe cataract. A cataract in which degenerative changes have occurred. The lens may become harder and smaller or calcareous with fatty granulations, or it may undergo partial absorption and shrink to a thin, hard, brittle disc.

Over-sightedness. Hypermetropia.

Owl. This avian form was once regarded as of the order *Accipitres* or *Raptores* (birds of prey), but it is now placed by some authorities in the *Coraciiformes* as the sub-order *Striges;* however, more recently as a separate order of *Strigiformes.* The head is very large; the skull is broad, the cranial bones highly pneumatic, and the facial region flattened; the beak is short, hooked, strong, and sharp, but

never notched. The eyes are very large, directed forwards, only slightly movable; the upper eyelid is very large, and both eyelids are ciliated with barbed plumelets, and have a broad, thin, bare margin; the third eyelid, or nictitating membrane, is conspicuous; the iris is unusually broad, and is capable of being greatly expanded and contracted. See **Birds, Eyes of,** p. 998, Vol. II, of this *Encyclopedia;* as well as under **Comparative ophthalmology.** A full account of the background of these human-like visual organs is to be found in Casey Wood's *Fundus Oculi of Birds*, Chicago, 1917.

Ox eye. Buphthalmos. See p. 1339, Vol. II of this *Encyclopedia.*

Ox-gall. See **Cow, The.**

Oxyblepsia. Abnormal acuteness of vision.

Oxycephaly, Ocular complications of. The state of having the head long or high, or with a high vertical index and a narrow transverse diameter, has long been recognized.

As Sharpe (*Am. Journ. Med. Sciences*, p. 840, June, 1916) points out, much confusion has arisen from the variety of names employed to designate the shape of the cranium—*ox-head, turritum caput, acrocephaly, Turmschädel, tower-skull, hypsicephaly, steeple-head, tower-head, etc.*

I. F. Stein (*Jour. Am. Med. Asso'n.*, p. 202, Jan. 17, 1914) notes that most of the cases reported, according to Fletcher, who reviewed the literature in 1910, were considered chiefly because of the curious cranial deformity. Fletcher found only between eighty and ninety cases, and since then a few more have been reported by Brav, Almond and von Schevensteen. This condition is probably more common than statistics would have us believe, only the severe cases—those in which there is early and rapid blindness—being usually reported.

Most of the observations of this condition have been made by ophthalmic surgeons, since patients are brought to them on account of failing eyesight and nystagmus; frequently, however, the cranial deformity has been overlooked. Von Graefe reported the first case in 1866 in an 8-year-old child, who had typical choked discs. Sharpe says that the cranial deformity is usually not considered important enough to warrant a professional opinion, unless there is impairment of the vision, and it has been observed that the greater the deformity, the greater the eye disturbance. A premature synostosis of the occipital, parietal and temporal bones has been ascribed as the probable cause of this condition. The union of these bones has allowed brain expansion only in the direction of the anterior part of the skull, producing either the high *Turmschädel* type, or, in severe cases, the bulging prominence at the anterior fontanelle of the oxycephalic type; the

resulting increase in the intra-cranial pressure producing choked disc and subsequent optic atrophy. In these cases the intelligence is not impaired. As possible mild types of "tower" skull, Patry cites, as examples, the skulls of Sir Water Scott, Paracelsus, William Humboldt, Mechel and others who had abnormally tall heads and who were exceptionally intelligent men. The three cardinal signs of the disease are (1) the cranial deformity, (2) exophthalmos with divergent strabismus, (3) impairment of vision. The author says that the exophthalmos is undoubtedly due to the very shallow orbit. The impairment of vision is always the result of secondary optic atrophy, and it is present in practically all of the cases.

The *treatment* should be directed toward a relief of the increased intracranial pressure; in the cases of the *Turmschädel type* of deformity of the skull there is usually no visual impairment, and the cranial deformity is slight because the intracranial pressure is not high; these cases do not require an operation.

In the *oxycephalic type* of cranial deformity, however, the increased intracranial pressure should not be allowed to produce the blindness of a secondary optic atrophy; an early relief of this increased pressure with the resulting avoidance not only of the cranial deformity but of the far more important impairment of the vision is advisable by means of the operation of cranial decompression; of the cranial operations to be used, the subtemporal decompression is the operation of choice.

See, also, **Cranial deformities,** p. 3553, Vol. V of this *Encyclopedia.*

Oxydases. These agents are oxidizing ferments which favor the transfer of oxygen to oxidizable bodies. They are found in all organisms, and are necessary to the maintenance of life, because they activate the atmospheric oxygen and render it capable of use in the biochemic mechanism. Coronedi has succeeded in producing a compound of manganese with nucleinic substances, which he calls "oxydasolo," and which according to his experiments possesses qualities resembling those of natural oxydases. It contains 6 per cent. of manganese and 6.5 per cent. of phosphorus.

The principal changes produced by its introduction into animals and man are a slight rise of temperature and a hyperleukocytosis. The hyperthermia does not appear after the second or subsequent doses, but the hyperleukocytosis is repeatedly produced. Gallenga has tested the effects of this artificial oxydase on infected corneal wounds in boys, injecting the drug hypodermically into the abdominal wall; in various cases of serpent corneal ulcer from the pneumococcus; and in two cases of keratohypopion in young babies, secondary to eczematous keratitis.

There was a prompt amelioration of the ocular conditions, with rapid absorption of the hypopion, dilatation of the pupil, arrest of the ulcerative process, and relief from pain.

Oxydasolo. In 14 cases of *kerato-hypopyon* following the work of Gallenga, Casolino (*Ophthalmic Year-Book*, p. 35, 1916) has employed oxydasolo, a new therapeutic agent which is a synthetic product of nucleinic acid with manganese, and the purpose of which is to supplement the normal oxydases or oxygen-liberating elements of the blood. Examination of the blood showed that after injections of oxydasolo there was a marked increase of the oxydasic granules of the blood. There was also produced a hyperleukocytosis, which was accompanied by a rise of temperature. The increase in the oxydases, as well as the hyperleukocytosis and the rise of temperature, reached their maximum intensity between the sixth and twenty-fourth four after the injection. With only one exception all the cases showed a marked tendency to resorption of the hypopyon and to cleansing of the serpent ulcer after the injection. Casolino concludes that the new preparation both increases the defensive powers of the organism, and stimulates the oxidising processes.

Oxyde azoteux. (F.) Nitrous oxide.

Oxyde mercurique. (F.) Mercury binoxide.

Oxyde mercurique jaune. (F.) Yellow mercury oxide.

Oxyde mercurique rouge. (F.) Red mercury oxide.

Oxyde nitreux. (F.) Nitrous oxide; nitrogen monoxide.

Oxyderces. (Obs.) Keen-sighted: also, promoting keenness of vision. As a noun in the nominative plural, *oxydercea*, remedies for strengthening the sight.

Oxydercia. (Obs.) Keenness of sight.

Oxyesthesia. ACROESTHESIA. Exaggerated sensibility (one of the phenomena of hysteria).

Oxygenated vaseline. See **Vasogen.**

Oxyopia. Acuteness of vision.

Oxytoluoltropine. See **Homatropine.**

Oysters, Toxic amblyopia from. PTOMAINE POISONING. A number of cases of miosis and ptosis have been observed to follow the consumption of "bad" oysters, aside from the occurrence of gastric and typhoid-like symptoms. In one case, described by Feilchenfeld in 1896, the consumption of canned oysters was followed in all the participants by inability to read (paresis of accommodation) aside from the characteristic general phenomena. This case is remarkable in that in spite of the paralysis of accommodation, the reaction of the pupil remained perfectly normal. Because of its similarity to atropin poisoning the

toxic effect of "tainted" oysters is classed by Husemann as *Zootrophotoxismus tropeinicus.* As in the case of decomposed fish, meat, cheese, and mussels the toxic amblyopia in oyster poisoning is an example of botulism. See p. 1253, Vol. II, and on p. 5208, Vol. VII of this *Encyclopedia.*

Ozena bacillus. The *bacillus fœtidus ozenæ* is occasionally found in the muco-purulent discharge from an infected lachrymal sac—including the congenital variety.

Ozonoscope. An instrument used for the exposure of ozonic test-papers.

P.

Pacheablephara. PACHYTES. (Obs.) Enlargement and thickening of the eyelid.

Pachometer. PACHYMETER. An instrument for measuring small thicknesses.

Pachyacria. See **Acromegaly,** p. 79, Vol. I of this *Encyclopedia.*

Pachyblepharon. Thickening of the lid, especially of the free border.

Pachydermia lymphangiectatica. See **Lymphangiectasis, Ocular.** p. 7558, Vol. X of this *Encyclopedia.*

Pachymeningitis. See *Meningitis* under **Neurology of the eye,** p. 8342, Vol. XI of this *Encyclopedia.*

Pacini, Filippo. A celebrated Italian surgeon, who devoted considerable attention to ophthalmology. Born May 25, 1812, at Pistoja, he there studied medicine and was early distinguished as an original investigator. In 1840 he settled in Pisa, where he was assistant to Prof. Savi. Not finding in Pisa the recognition to which he was entitled, he removed to Florence, where he was made professor of descriptive and artistic anatomy. His most important contribution to ophthalmology was: "Nuove Ricerche Microscopiche sulla Tessitura Intima della Retina" (Bologna, 1845). He was the first in this article to describe the outermost, thin nerve-fibres of the granular layer of the retina. His writings on anatomy and physiology in general are very numerous, and, for the most part, valuable. Pacini died in 1883.—(T. H. S.)

Padiaur, Anton. A Bohemian ophthalmologist and oto-laryngologist. The date and the place of his birth are not now ascertainable. Padiaur died, however, at Eger, Bohemia of "blood poisoning," Feb. 9, 1902, aged either thirty-eight or thirty-nine years.—(T. H. S.)

Pagan, Count de. His full name was Blaise François de Pagan. He was born of a well known family at Avignon, France, in 1604. He joined the army when very young, and, soon after, lost the sight of an eye by a gunshot wound at the siege of Montaubon in 1621. Being

sent to Portugal in command of the French troops, he there fell sick of a fever, and soon was totally blind.

After the onset of his blindness, he left the army, thereafter devoting his undivided energies to military science and astronomy. His most important writings are: "A Treatise on the Art of Fortification," "Geometrical Theorems," "Theory of the Planets," "Astronomical Tables."

He was the first to propound the principle of vertical firing—a very important discovery.

He was a brave, kind and gentle man, of most industrious habits, whose life was perhaps more useful after his entrance into "the great dark" than it even had been before. He never married. He died in 1665, aged 61.—(T. H. S.)

Pagenstecher, Alexander. A famous German ophthalmologist, whose name is inseparably connected with the so-called "Pagenstecher's ointment." Born April 21, 1828, at Wallau, near Wiesbaden, he studied at Giessen, Heidelberg and Würzburg, at the latter institution receiving his degree in 1849. In 1851 he studied ophthalmology at Paris under Desmarres and Sichel and in 1852 at Berlin. Settling in Weisbaden, he founded an Eye Infirmary for the Poor, which soon had a great reputation. In 1857 he became court councillor. He published in conjunction with Saemisch (Bonn), Hirschmann (Charkow), and Berlin (Stuttgart), the justly celebrated *Klinische Beobachtungen aus der Augenheilanstalt in Wiesbaden* (Wiesbaden, 1861-62). He was killed while hunting, by the accidental discharge of his gun, Dec. 31, 1879.

Pagenstecher wrote but little. In fact, his only ophthalmologic writing, aside from that already mentioned, was a rather short article entitled "Zur Iridodesis" (Graefe's *Archiv*, VIII). He was, however, a wonderful operator, and many are the stories that are told concerning his skill.

Pagenstecher was a little, wizened man, who wore long hair and a full beard. He was a man of warm heart, and was specially kind to the poor and to the younger members of his profession.—(T. H. S.)

Pagenstecher, Karl. A well known general practitioner of Elberfeld, Germany, who devoted especial attention to diseases of the eye, and who achieved a considerable reputation as an ophthalmic operator. Born at Nassau a. d. Lahn, Jan. 13, 1824, a son of the well known physician, Heinrich Pagenstecher, he studied at Bonn, Göttingen, and Berlin, receiving his medical degree at Berlin in 1845. Having studied ophthalmology at Prague, Vienna, and Paris, he settled in 1847 at Elberfeld, where he practised until his death, at no time, however, re-

linquishing general practise entirely. For a number of years he spent each summer in study with Albrecht von Graefe. In 1862 he became Superintendent of the Elberfeld City Hospital. His chief ophthalmic writing is "Ueber Verletzungen der Linsenkapsel," (*Zehender's Klin. Monatsb.*, II). Pagenstecher died on June 15, 1865.—(T. H. S.)

Pagenstecher's ointment. PAGENSTECHER'S SALVE. See **Mercury, Yellow oxide of,** p. 7655, Vol. X of this *Encyclopedia.*

Pagenstecher's operation. Intracapsular extraction of cataract. See p. 1511, Vol. III of this *Encyclopedia.*

Paget's disease. OSTEITIS DEFORMANS. See **Leontiasis ossea**, p. 7420, Vol. X of this *Encyclopedia.* In addition to that discussion of this rare disease Jules Vergne (*Annales d'Oculistique*, Nov., 1908) found in all the three cases he describes a chorioretinitis of undoubtedly luetic origin. He also attributes the osteitis deformans to hereditary syphilis.

Coppez (*Archiv. d'Ophtalmologie*, p. 530, Vol. XXXII, Sept., 1912), describes the ocular complications which he has seen in four cases of Paget's disease. The changes consisted in fine spots of a yellowish color, and about the size of a pinhead in the upright image, situated in or near the macula. In one case small hemorrhages were added to the spots. Metamorphopsia was present in all cases, likewise lenticular changes. In one case there was diplopia, due to the displacement of the pulley of the superior oblique by the osseous growth. The patients were all middle aged or old, and were suffering with chronic gout or rheumatism. Wassermann was negative in all cases. Therapy was of no avail. The macula being one of the parts of the economy sensitive to trophic disturbances, it does not surprise one to find these changes in a disease involving so many trophic disturbances in other parts of the body.

Pain, Ocular. This symptom is of some importance from the standpoint of both causation and prognosis. It has been fully discussed under various captions in this *Encyclopedia.* With many others Morax has classified it as follows: (1) *Superficial pain* including that attending affections of the lids and lachrymal apparatus; that of affections of the conjunctiva and cornea, in which there is a sensation of a foreign body; and the pain of iritis and cyclitis. (2) *Deep pain,* including that of hyper-tension, suppurative inflammations of the eyeball, the tenderness of retrobulbar neuritis; pain attending orbital disease, and that arising from the fifth nerve or Gasserian ganglion. (3) Pain arising from certain neuropathic states, accompanied with free secretion of tears, and absence of other ocular disease. (4) The pain arising from eye-strain, including ophthalmic migraine.

Pain reaction, Ocular. SENSORY REFLEX. SKIN-REFLEX. When the

branches of a sensory nerve are stimulated by pinching the skin both pupils dilate.

Painters and painting. The vision and especially the color-sense of artists have been much discussed by ophthalmic writers, and the color peculiarities of such men as the painter Turner have been explained on the score of their chromatic defects. For instance, Angelucci (*Ophthalmic Year-Book*, p. 38, 1909) from a collection of paintings by artists whom he has examined and found color-blind, has worked out the following characteristics of such pictures. As pointed out by Liebreich, green is used for the shaded parts of flesh, while the lighter parts may be too red. When, by practice, the color-blind artist learns to use red correctly, green is still too freely used. By the absolutely color-blind, purple may be used to represent flesh, and by the red-green blind it is used in shadows. Differences of green are exaggerted; in high lights becoming yellow, in shadows blue. There is excessive mixing of colors. When, however, the color-blind learn to diminish their color defects, and become expert in drawing and perspective, their pictures are so powerful in light and shade that the relief effects resemble those of the great masters.

G. Beritens (*Archivos de Oftalmologia*, March, 1913) also points out other peculiarities. The Prado gallery at Madrid contains a number of works by the famous painter of the 16th and 17th centuries, Dominico Theotocopuli, better known as El Greco. Apart from other characteristics, the works of El Greco are strikingly peculiar in an elongation of many of the figures they contain. From a study of the Prado pictures, and of reproductions of others by the same painter, Beritens seeks to show that this distortion was due, not as some believe to a mental bias of the artist, but a high astigmatic error. The elongation is apparently confined to the vertical direction, being especially marked in the faces, but also noticeable in other parts, such as the hands. When faces are shown oblique or prostrate, instead of vertical, the exaggeration of the vertical proportion still seems to hold, the face in these instances thus becoming rounder than when seen erect. In the works belonging to successive periods of the artist's career, Beritens traces the influence of gradually weakening accommodative power in diminishing distinctness of detail and increasing the astigmatic distortion in favor of the vertical lines. He even ventures to transfer to certain periods of the artist's development works which by the critics have hitherto been regarded as belonging to other periods. El Greco was apparently also affected with divergent strabismus of the right eye.

Paleo-ophthalmology. The ophthalmology of ancient times. The term

has been objected to, but without good reason, on the ground that it might possibly be mistaken for "paleontologic" ophthalmology, a term of very different meaning.—(T. H. S.)

Paleontologic ophthalmology. The ophthalmology of extinct forms of life. Not to be confounded with "paleo-ophthalmology." See **Comparative ophthalmology.**

Palette d'essai. (F.) Trial frame.

Pallen, Montrose Anderson. A New York gynecologist, who devoted considerable attention to ophthalmology. Born at Vicksburg, Va., Jan. 2, 1836, son of a well-known gynecologist, Moses Montrose Pallen, he received his medical degree at St. Louis University in 1856. After a number of years spent in graduate work at London, Paris and Berlin, he settled in New York, where he soon became professor of gynecology at New York University.

He wrote a number of journal articles on "Iridectomy" and "Corneitis"; also a prize essay, *The Ophthalmoscope* (1858).—(T. H. S.)

Pallet, Cabini's. See p. 1350, Vol. II of this *Encyclopedia*.

Pallidin reaction. As George Coats (*Ophthalmic Review*, p. 282, Sept., 1914) points out the search for a simplification of the Wassermann test has evoked the luetin and the pallidin reactions. The former, as is well known, is a cutaneous reaction produced by an extract of a pure culture of the spirocheta pallida. In the latter, which is also a cutaneous reaction, a sterilized suspension of spirochetes extracted from syphilitic organs is used. From numerous researches on the relative efficiency of these tests it would appear that the Wassermann reaction must still be regarded as the most generally applicable, but that each of the others is capable of giving valuable confirmatory or adverse testimony in particular cases. In late hereditary syphilis and parasyphilis, for instance, the luetin reaction is not infrequently positive while the Wassermann reaction is negative; but the value of this observation is somewhat diminished if it be true, as has been stated, that the former reaction is also positive in about 1 per cent. of non-syphilitic cases.

The pallidin test, according to Klausner (*Klin. Monatsbl. f. Augenheilk.*, 52, p. 813, 1914) is useless in early syphilis, but gives a highly characteristic reaction in the gummatous stage and in late hereditary syphilis.

Applying the test to a number of ophthalmic cases Klausner found both the Wassermann and pallidin reactions positive in 9 cases; the pallidin reaction positive while the Wassermann was negative in 11; the pallidin negative and the Wassermann positive in 7. From the standpoint of the type of disease the discrepancies in iridocyclitis,

papillitis, retinitis, retino-choroiditis and scleritis were of minor importance; but more interest attaches to the case of interstitial keratitis. Among instances of this disease four gave a positive result with both tests. In eight the pallidin reaction was positive, the Wassermann negative, and of these three had previously given a positive Wassermann reaction which had become negative after energetic treatment; in a fourth the serum of the mother gave a positive Wassermann reaction; in a fifth the Wassermann reaction subsequently became positive, probably owing to the absorption of small quantities of dead spirochetes from the pallidin test; four of the cases showed the typical stigmata of hereditary syphilis.

From all this it would seem that in cases of late hereditary syphilis the pallidin reaction is the more delicate of the two and that a positive result with it would justify a diagnosis of syphilis, in a case of interstitial keratitis, even if the Wassermann reaction were negative.

Pallidus color virgineus. (L.) Chlorosis.

Pallucci, Natalis Giuseppe. A once famous Viennese surgeon and ophthalmologist. Born at Florence, Italy, in 1719, he studied medicine in Italy, was appointed body-surgeon to the Grand Duke of Tuscany, practised for a time in Paris and then removed to Vienna where he became an Imperial Royal Surgeon, and spent the remainder of his life. He died July 28, 1797.

As a cutter for stone he was unexcelled, but his chief performances were in the field of ophthalmology. Never a convert to the extraction method of dealing with cataract, he invented a very original instrument with which to perform the depression operation. It consisted of a trocar-canula. When the trocar was in place, the device was used to perforate the sclera. As soon, however, as the proper opening had been made, the trocar was withdrawn well back into the tube, leaving in the scleral perforation a blunt-ended canula with which the operation was completed without the slightest fear of injury to the iris or the ciliary body.

Palucci's ophthalmologic writings are as follows: 1. Description d'un Nouvel Instrument pour Abattre la Cataracte, avec Tout le Succés Possible. (Paris, 1750; German trans., Leipsic, 1752.) 2. Histoire de l'Operation de la Cataracte Faite à Six Soldats Invalides. (Paris, 1750.) 3. Méthode d'Abattre la Cataracte. (Paris, 1752.) 4. Lettre à M. le Marquis de . . . sur les Opérations de la Cataracte Faites par M. Pallucci. (Paris, 1751.) 5. Methodus Curandae Fistulae Lacrymalis. (Vienna, 1762.) 6. Descriptio Novi Instrumenti Pro Cura Cataractæ. (Vienna, 1763.)—(T. H. S.)

Palma Christi. Ricinus communis. The leaves of the castor oil plant,

with pealed barley, or macerated with wine, were applied to the eyes in all diseases accompanied by profuse discharge. The leaves alone were used as a poultice in epiphora.—(T. H. S.) See, also, p. 1436, Vol. II of this *Encyclopedia*.

Palmer, Arthur Worrall. A well known homeopathic ophthalmologist and oto-laryngologist of New York City. Born in New York City June 27, 1861, son of Dr. Miles Wesley and Hannah Worrall Palmer, he received his early education at the Friends' Seminary and at the City College. The degree of M. D. was received by him in 1883 at the New York Homeopathic Medical College and Flower Hospital, and that of *Oculi et Auris Chirurgus* at the New York Ophthalmic and Aural College in 1885. From that time onward he devoted himself exclusively to ophthalmology and oto-laryngology in New York City.

Dr. Palmer was a member of the American Institute of Homeopathy, the American Homeopathic Ophthalmic, Oto-and Laryngological Societies, the American Medical Editors' Association, the National Society of Electro-therapeutics, the New York State Homeopathic Medical Society (since 1899), the Hahnemannian Association, the Academy of Pathological Science, the New York County Homeopathic Medical Society, and the Alumni Association of the New York Homeopathic Medical College and Flower Hospital. He was surgeon and professor of laryngology and rhinology at The New York Ophthalmic Hospital, and laryngologist to The Metropolitan Hospital and to The M. E. Church Home. He was, for many years, assistant editor of the *Journal of Ophthalmology, Otology, and Laryngology,* and in 1900 became its business manager as well. In 1904 he bought the *Homeopathic Eye, Ear and Throat Journal*, which, in conjunction with Dr. John L. Moffat, he edited for six years—i. e., until, in 1911, it was merged in the revived *Journal of Ophthalmology, Otology and Laryngology*. From 1911-1914 he was proprietor, business manager, and, in conjunction with Dr. Moffat, the editor of the "*Journal.*"

In 1892 Dr. Palmer married Miss Elizabeth B. Giveans, of Vernon, N. J.

Because of failing health, Dr. Palmer, in June, 1913, retired from practice. He died June 10, 1915, of pernicious anemia after an illness of more than two years. He was survived by his widow, his son, A. W., jr., and his sister, Miss Luella A. Palmer.

Regarding his personal character, we quote the following from his long-time friend and business and professional associate, Dr. John L. Moffat: "Dr. Palmer was so modest and unassuming that one had to know him well to appreciate him. The writer can say that in a close business association of sixteen years there was never a hitch in the

friendship; he never experienced even a hasty word from Dr. Palmer. His characteristics were faithfulness, conscientiousness, studiousness. An indefatigable worker and cautious operator, he took his recreation in his professional and journalistic work, to which fact we fear his illness was attributable—at least in part."—(T. H. S.)

Palming. A method of treatment applicable to the eyes described by Wm. H. Bates (*N. Y. Medical Journal*, p. 201, Feb. 3, 1917).

Palpebra. (L.) Lid.

Palpebra ficosa. An old term for a fleshy, papillomatous excresence on the eyelid, often soft and reddish, but sometimes hard, hanging by a peduncle, and shaped something like a fig.

Palpebra inferior extrorsum flexa. Ectropium of the lower eyelid.

Palpebral. Pertaining to the eyelid.

Palpebral cartilage. A name for the tarsus or plate of connective tissue in the substance of the lid.

Palpebral commissures. The external and internal canthi.

Palpebral conjunctivitis. Conjunctivitis confined to the palpebral conjunctiva.

Palpebral fissure. The space between the lids. See p. 5209, Vol. VII of this *Encyclopedia*.

Palpebral flux. An old term for the sebaceous discharge from inflamed Meibomian glands.

Palpebral follicles. Meibomian glands.

Palpebralis. An old term for the orbicularis palpebrarum.

Palpebral ligaments. See p. 7469, Vol. X of this *Encyclopedia*.

Palpebral reflex. Same as *Gifford's reflex;* see p. 5384, Vol. VII of this *Encyclopedia*.

Palpebra major. The upper eyelid.

Palpebra minor. The lower eyelid.

Palpebrate. To wink; having eyelids.

Palpebra tertia. Plica semilunaris.

Palpebratio. (L.) Nictation.

Palpebration. The act of winking; abnormally frequent winking.

Palpebrine. A proprietary antiseptic containing boric acid, morphia, mercuric bichlorid, zinc sulphate, and glycerin; used in conjunctivitis and other eye inflammations.

Palpebritis. A synonym of *blepharitis*.

Palpebrous. Having prominent superciliary ridges.

Palsy. See **Paralysis**; as well as **Paresis.**

Palsy, Bell's. Facial paralysis. See p. 926, Vol. II of this *Encyclopedia*.

Palsy, Féréol-Graux type of ocular. Associated paralysis of the internal rectus muscles of one side and the external rectus of the other.

Palucci's cataract knife. A knife shaped like a Beer's knife, but much narrower, which can be pushed forward along a lance-shaped needle.

Pamard, Jean Baptiste Antoine Benezet. Son of Pierre François and father of Paul Antoine, Pamard, and himself a famous Avignonese ophthalmologist. Born at Avignon, France, April 11, 1763, he studied first at Avignon, there receiving the degree of Master of Surgery in 1782. For a time continuing his studies at Paris, he settled at Avignon in 1787. He became lauriate of the Royal Society of Surgery, and died in 1787.

In addition of a number of general works, in particular a "*Topographie Physique et Medicale d'Avignon,*" he wrote the following: 1. Observation sur une Fistule Lacrymale, Opérée par un Procédé particulier avec le Journal du Traitement qui a Suivi l'Opération. (*Annales de la Société Pratique de Montpellier,* an XI 1803.) 2. Observation sur un Accident d'Apoplexie Survenu par Inanition aprés l'Opération de la Cataracte et Guéri Simplement par l'Usage des Aliments. (*Ibid.*, an XI 1803.) 3. Phénomènes Particulières et Curieux qu'A Présentés, un Iris dans une Opération de Cataracte. (*Ibid.*, 1808.)—(T. H. S.)

Pamard, Paul Antoine Marie. A famous Avignonese ophthalmologist, son of Jean Baptiste Antoine Benezet, and grandson of Pierre François Benezet, Pamard. Born at Avignon, Aug. 2, 1802, he studied at Montpellier and Paris, receiving the degree of Doctor of Medicine and Surgery in 1825. He settled in Avignon, where he succeeded his father as surgeon to the hospital. He was elected mayor of the city in 1853, and national deputy in 1861. His death occurred April 13, 1872.

His ophthalmologic writings are as follows: 1. De la Cataracte et de son Extraction. (*Thèse de Paris,* 1825.) 2. Relevè de Clinique Chirurgicale de l'Hôpital Civil et Militaire d'Avignon pendant le Premier Trimestre, 1831. (*Transacts. Méd.,* Paris, 1832.) 3. Recherches sur le Traitement de Diverses Maladies des Yeux. (*Révue Médicale,* 1834.) 4. Réponse à la Question Posèe par Serre d'Uzès: Quelle est l'Influence de l'Operation de la Cataracte sur la Vie de ceux qui a Subissent? (*Annal. d'Ocul.* 1839, Vol. II, p. 230-232.) 5. Observations Ophtalmologiques. (*Annal. d'Ocul.* 1841, Vol. V, p. 157-163.) 6. Mémoire sur l'Iritis. (*Mém. de Chirurgie Pratique,* Paris, 1844.) 7. De la Cataracte et de son Extraction par un Procédé Particulier. (*Mém. de Chirurgie Pratique,* Paris, 1844, p. 1-79.) 8. Observations Ophtalmologiques propres à Infirmer l'Opinion Générale Admise de la Nature Cancéreuse des Mélanoses. (*Annal. d'Ocul.*, 1853, Vol. XXIX, p. 25-31.) 9. De l'Opération de la Cataracte chez les

Vieillards. (*Annal. d'Ocul.*, 1854, Vol. XXXI, p. 224-228.) 10. Corps Étrangers de l'Oeil. (*Annal. d'Ocul.* 1860, Vol. XLIII, p. 23-29.)—(T. H. S.)

Pamard, Pierre François Benezet. A famous Avignonese surgeon of the 18th century, son of Nicolas Dominique Pamard, grandson of Pierre Pamard, father of John Baptiste Antoine Benezet, and grandfather of Paul Antoine Marie, Pamard. All these five Pamards were surgeons, without a single failure in the succession. Moreover, the subject of this sketch was also known in ophthalmology, and his grandson, Paul Antoine Marie (q. v.) was a celebrated specialist in our field; a truly remarkable record for a single family.

The subject of this sketch was born at Avignon, April 7, 1728, according to Pagel; but April 27, 1728, according to True and Pansier and to Hirschberg. He became master of surgery at Avignon, Feb. 13, 1744, and studied later at Montpellier. Going to Paris, he became a demonstrator of anatomy, but soon returned to Avignon. He grew famous as an operator, and had an enormous practice. He became Consul at Avignon in 1776, and died there Jan. 2, 1793.

Pamard is specially to be remembered in the history of cataract. As early as 1758 he began to employ the extraction method of Daviel, but soon was aware of its very obvious defects. We are therefore indebted to him for the following truly great improvements in the cataract operation: 1. The adoption (for the patient of course) of the dorsal decubitus during the cataract extraction. As pointed out by Hirschberg, he had been preceded in this matter both by Poyet and the Arabs; still, he revived the dorsal decubitus in the cataract operation, and gave to it its first great vogue. 2. The "trèfle," an instrument devised to effect fixation of the eyeball. This instrument was implanted in the cornea, about 2 millimetres from its limbus. One should, in this connection, recall the fact that Daviel and those who first repeated his extraction operation, performed fixation of the bulbus by means of a finger pressed loosely against the nasal aspect of the organ. 3. The triangular knife. In addition to the lance of Daviel, Pamard had tried La Faye's knife, and, though he found it a great improvement over the crude affair of Daviel, yet he also discovered that, in it, there also inhered a number of disadvantages, the chief of these being that, because of the narrowness of the blade, the iris would often fall across the edge and so be wounded. Pamard's knife was "a blade two lines and a half in width with a back wholly blunt, except at the very point, where, in order to give to the instrument a greater penetrating power there was a short edge. The width of the

blade, providing an adequate support to the iris, holds that structure in its proper place."

Pamard did not write much. In addition to three or four articles on cataract extraction, he published "Diss. sur quelques Effets de l'Air dans nos Corps"; also a "Description d'une Seringue Pneumatique et ses Usages dans quelques Maladies Tres-Frequentes avec des Observations" (Avignon, 1791).—(T. H. S.)

Pan-. A prefix signifying "all."

Panacea. A universal remedy.

Panas, Photinos. A celebrated Anglo-Greco-Parisian ophthalmologist. Born Jan. 30, 1832, at Cephalonia, one of the Ionian Islands, while they were under British sovereignty, control and influence. He studied his profession at Paris, there receiving his medical degree in 1860. His thesis on this occasion was entitled "Recherches sur l'Anatomie des Fosses Nasales et des Voies lacrymales." About this time he became a French citizen. In 1863 he was made associate professor *(agrégé)* and surgeon of the Central Bureau, his thesis being "Des Cicatrices Vicieuses et des Moyens d'y Rémédier." In 1864 he was made surgeon at the Bicetre, in 1864 at Lourcine, and also at du Midi, in 1868 at Sainte-Antoine and Saint-Louis, in 1872 at Lariboisière, and in 1879 at the Hôtel Dieu. In 1873 he began to lecture on ophthalmology, and in 1879 was made titular professor of the subject. His name is intimately connected with operations for the relief of ptosis, entropion, etc.

According to Hirschberg, the six great achievements of Panas may be stated as follows: 1. The ophthalmic clinic of the Faculty. 2. The best French textbook on ophthalmology which was written in the "Reform" period. 3. Together with others, the founding of the "*Archives d'Ophtalmologie*" (1881) the first organ of our specialty originally established on French soil, which, in twenty-one volumes, bears witness to the progress of ophthalmology in France. 4. Together with others; "The French Society of Ophthalmology" (1883) whose reports in twenty-one volumes record a vast amount of research and its results. 5. Ophthalmic appointments in the other great hospitals of Paris. 6. A new French school of ophthalmology, which united the hospital and the laboratory.

Panas died on Jan. 6, 1903, and was succeeded by de Lapersonne.

Panas's ophthalmic writings are as follows: 1. Leçons sur le Strabisme et les Paralysies Oculaires. (1873.) 2. Leçons sur l'Anat., la Physiol. et la Pathol. des Voies Lacrymales. (1876.) 3. Leçons sur les Maladies Inflammatoires des Membranes Internes de l'Oeil. (1878.) 4. Leçons sur les Rétinites et les Nevrites Optiques. (1878,

with figures.) 5. Anatomie Pathologique de l'Oeil. (1879, with 26 plates, in collaboration with Rémy.)—(T. H. S.)

Panax. An Arabian plant, no longer identifiable, whose juice, called "opopanax," was used in a general way, in ancient Greco-Roman times, as a strengthener of the sight. The leaves were also employed as a poultice for ægilops (fistula of the lachrymal sac).—(T. H. S.) See, also, **Opopanax.**

Pancoast, Joseph. A distinguished American surgeon, of some importance in ophthalmology. Born in Burlington County, New Jersey in 1805, he received his medical degree at the University of Pennsylvania in 1828. He settled in Philadelphia, and soon was widely celebrated as anatomist and surgeon. In 1831 he began to teach practical anatomy and surgery. In 1834 he was made physician to the Philadelphia Hospital, Blockley; in 1835 he became physician-in-chief to the Children's Hospital. In 1838 he was elected professor of surgery in the Jefferson Medical College. Six years later he published his "*Treatise on Operative Surgery*," on which his fame as an author chiefly rests.

Pancoast was much more widely known in the general surgical than in our special field; and yet he performed many ophthalmic operations. He also devised several operations on the eye, as well as a number of useful eye instruments. The Pancoast needle for soft and mixed cataracts is still in common use; so is the Pancoast operation for the restoration of the eyebrow. Pancoast was in fact the first to demonstrate that, in extreme cases of internal strabismus, "the tendon of the inferior oblique muscle is often girdled by rigid connective tissue," and that this tendon must be divided before the eye can turn to its normal position. For occlusion of the nasal duct he punctured the lachrymal sac and introduced a hollow ivory tube from which the earthy matter had been removed, and left it *in situ* to dissolve.

Pancoast taught in Jefferson Medical College for more than thirty-six years. He married, in 1829, Rebecca, daughter of Timothy Abbott. William Henry Pancoast, long a professor at the Jefferson Medical College, and, later, at the Medico-Chirurgical College, in the same city, was their son. The father died at Philadelphia, Mar. 7, 1882.—(T. H. S.)

Pancratic eyepiece. An eyepiece of variable magnifying power.

Pancreatine. In the pancreatic juice of warm-blooded animals there are at least four digestive ferments, as follows: Trypsin, a proteolytic ferment, acting in an alkaline medium, that converts proteids, albumen and fibrin, e. g., casein of milk, into peptones but digests white of eggs with difficulty. Amylopsin or pancreatic diastase that converts starch into dextrin, maltose and dextrose. Steapsin, lipolytic ferment that

emulsifies fats. Rennin, a milk-curdling ferment converting casein into a form of peptone.

Much of the pancreatine used in America is manufactured by Parke, Davis & Co., and Fairchild Bros. & Foster. It is marketed by them as pure pancreatine, an almost insoluble, cream-colored, amorphous powder with a faint odor and meaty taste, as tablets or as a peptonizing mixture. It is nearly always prescribed with bicarbonte of sodium.

The ophthalmic surgeon is interested in these digestive ferments owing to their alleged power of curing, or relieving, the suffering that accompanies malignant growths. The same rules that apply to the conduct of extraocular, malignant neoplasms should be followed in the treatment of carcinoma and sarcoma of the eye structures. Especially after simple enucleation or complete exenteration of the orbit for any form of malignancy it has always seemed rational that the use of either radium, the X-rays (q. v.) or pancreatic ferments (or all) ought to be encouraged.

Panel lens. A lens designed for making panel photographs.

Panizza, Bartolomeo. A famous Italian surgeon of moderate ophthalmologic importance. Born, the son of a physician, at Vicenza, Aug. 15, 1785, he received the degree of Doctor of Surgery at Padua. He afterwards studied at Bologna, Florence and Pavia. In 1812, becoming a surgeon in the army of Napoleon, he accompanied the Emperor's ill-starred expedition into Russia, and there was taken prisoner. On his release he returned to Pavia, where he attained, by competitive examination, the professorship of anatomy—a position which he held for forty-nine years. While in this position he discovered the gustatory functon of the glosso-pharyngeal nerve. He died April 17, 1867.

Panizza's only ophthalmic writing is entitled "Annotazioni Anatomo-Chirurgische sul Fungo Midollare del' Occhio e sulla Depressione della Cataratta." Pavia, 1821; a Supplement to the work, Pavia, 1826; Ger. trans., Weimar, 1828. This monograph contains the earliest account of an extirpation of an eyeball for medullary sarcoma of the retina.—(T. H. S.)

Pannus. Pannus in general. Pannus is a corneal condition secondary to several affections of the conjunctiva, of which disease it is really a symptom, but as its severity with regard to vision overshadows that of the primal cause and frequently proves fatal to eyesight, it deserves the distinction of being treated as a separate disease.

It has its origin fundamentally in trachoma, eczema and acne rosacea and usually invades the superior half, but sometimes the entire cornea. Deviated cilia will produce pannus.

At first the newly-formed vessels are situated beneath Bowman's

membrane; except when pannus is the result of keratitis parenchymatosa, the vessels, like the disease, are situated in the *substantia propria.*

When the vascularization is slight, or superficial, it is termed *pannus tenuis;* when severe, it is referred to as pannus *vasculosus*, or *pannus carnosus*. When quite fleshy it is sometimes called *pannus sarcomatosus.*

Herbert has shown that the whole corneal surface will frequently stain with fluorescein, proving that the process is sufficiently extensive to involve the entire corneal surface.

In typical cases, minute ulcers develop at the corneal margins, sometimes so numerous that they coalesce and form large ulcerating areas. The depth of the process is in accordance with the extent of disintegration. Pannus is really Nature's protective attempt to avoid further invasion and destruction of the cornea, and that it exercises a marked influence upon the prevention of infection, is well recognized. Sometimes pannus shows no tendency to disappear or suppurate and becomes permanent.

Granular pannus is characterized by its extreme persistence and, when not correctly treated, may last for years and destroy the sight by permanent maculæ if they encroach upon the pupillary area of the cornea. This form is sometimes so severe in its nature that the cornea has a fleshy, granulating appearance, which means that the process has pervaded the deeper corneal strata which become thinned and weakened and may therefore succumb to the intraocular pressure. Non-vascular follicles are sometimes found in the midst of the granular tissues. If microörganisms invade the corneal tissues, they cause suppuration (usually at the center) which terminates in perforation with all the attendant destructive sequelæ.

Pannus crassus is a form which develops in old cases at the site of former corneal opacities. It is characterized by well developed nodular elevations which coalesce and their margins overlap the sclera which becomes highly inflamed, thickened and very vascular. The term *pannus siccus* is applied to old quiescent cases of pannus.

Komoto (*Ophthalmic Year-Book*, p. 152, 1910) has examined histologically a large number of cases of trachomatous pannus in all stages of the disease. His report is at variance with those of Fuchs, Bietti and Raehlmann, who all observed infiltration under Bowman's membrane. He always found the cell-infiltration to be external to the membrane whenever the latter was present. Only at points where the membrane was perforated were cellular accumulations to be observed beneath. In general, however, Bowman's membrane shows but weak

powers of resistance, and soon disappears. Splitting up or thinning does not occur. Epithelial papillary structures were frequently encountered entering like processes into the infiltrated corneal tissue and forming nests. The epithelium was infiltrated with leucocytes.

Brueckner has made a careful clinical study of the corneal vessels, especially of the deep-seated varieties springing from the deeper marginal loops. The vessels which spring from the superficial series of marginal loops assume a branching arborescent arrangement, while those developing from the deeper network run in parallel lines as their course lies between the corneal lamellæ. The deep-seated veins are larger than the arteries; with the weak magnifying powers often

Pannus from Scrofulous Keratitis.

only the veins are visible. While the parallel vessels are usually deeply seated, and probably spring from larger vessels in the neighborhood of the canal of Schlemm, parallel vessels may sometimes be observed arising from the superficial episcleral loops, and coursing in the anterior layers of the parenchyma. This is not uncommon in eczematous keratitis. Anastomoses between the superficial and deep vessels are unusual. It may occur in deep-seated scars and has been observed in parenchymatous inflammations. Such anastomoses as occur are mostly venous. While the superficial vessels develop as individual sprouts from the episcleral vessels, the deep-seated variety is an arteriovenous loop from the beginning. They appear in a few days in eczema, but are later appearing in ulcus serpens and other infected ulcers.

During the active stage of corneal inflammation the movement of the blood column cannot be seen, but when the irritation is beginning to subside it becomes visible. The appearance of movement in the vessels is due to the slowing of the blood current and coincides with the beginning of resolution. The different stages are easily observed

in the jequiritol treatment; some differences are to be seen in observations made twelve hours apart. In the veins the movement is centrifugal in respect to the corneal center. In oblique vessels the movement is from right to left; in vessels not radial it is first in one direction and then in the other. In some vessels approaching in size to capillaries a rhythm is to be observed, corresponding to the radial pulse.

It is doubtful if the new-formed blood vessels ever become completely obliterated, for, when a new irritation appears, vessels of large size develop within twenty-four hours. The author ascribes to the blood vessels the function of nourishment and repair, even in parenchymatous disease. They are of value in the clearing of opacities, for a clear area is to be seen surrounding each vessel. He thinks that the vessels may protect the parts of the cornea surrounding the ulcer from invasion of toxines from the focus, by bringing to the part some substances antagonistic to the toxines. The invasion of the cornea by vessels during iritis he thinks may also have a prophylactic effect. He does not consider the finding of deep parallel vessels as pathognomonic of old parenchymatous syphilitic inflammation, as he has seen them also in eczema. The vascularity bears no relation to the sort of bacillus present in ulceration. But in general the worse the infection the greater will be the number of blood vessels. The deepest vessels are pathognomonic of irido-cyclitis, and are often seen in ulcus serpens and parenchymatous keratitis; deep vessels localized in the lower half of the cornea are typical of the irido-cyclitis of endogenous nature.

It has for some time been recognized that pannus is a specific trachomatous affection of the cornea. Follicle formation has been observed by Saemisch and others. It is found by Meyerhof, in Cairo, to occur at any stage of the disease. Generally, after the trachoma has been in progress for several months, there appear on the corneal side of the limbus, small, yellowish-red, translucent nodules, associated with a keratitis. These follicles when they heal leave pits, which are often pigmented in Egyptians, as is also the case among the inhabitants of India, according to Herbert. Megardi verifies the observations of other investigators who found that trachomatous pannus may penetrate the anterior corneal lamellæ.

Treatment. Except in neglected cases, pannus usually disappears with the causative disease unless the corneal infiltration and ulceration have been unusually rapid and extensive. Treatment is either directed against the cause, its effect, or both. Atropin is frequently indicated. Partial or complete peritomy is valuable in selected cases.

For the use of *jequirity*, see p. 6721, Vol. IX of this *Encyclopedia.*

Hagemann caused the disappearance of trachomatous pannus with

five applications of copper iontophoresis using a half per cent. solution of copper sulphate and a current of three milliamperes for three minutes. Grueter recommends an ointment of arsenophenyglyzin 2-5 per cent. for its absorbent action in scrofulous and trachomatous pannus.

Goldzieher (*Pract. Med. Series*, p. 74, 1909) comments on the unsatisfactory results usually obtained in the treatment of pannus crassus. He gives the history of the employment of jequirity and of *gonorrheal secretion* for this purpose. He narrates the history of one case of this sort, in which the results were surprisingly good, and in conclusion states: "From this case and two others previously treated on similar lines, I can draw the conclusion that the long-discontinued Jaeger inoculation of blennorrhea can be applied as an ultimatum refugium. It is by no means more dangerous than a jequirity-caused ophthalmia. The conclusive indication for its application is the presence of pannus crassus. It is worthy of special mention that after the disappearance of the inoculated blennorrhea not only has the cornea cleared up but—in opposition to the results arrived at with jequiritol—the conjunctival tract has also regained its soundness." However the introduction of jequiritol and our improved technic in the use of jequirity itself, do not seem to warrant this (as most of us believe to be) most dangerous procedure. It will require a number of additional observations before the ancient and rejected method of employing gonorrheal pus can be justified.

The removal of pannus by rasping is recommended by Frost. When the line of demarcation of cornea and sclera is not visible he prefers to cut down to clear corneal tissue and slice off the pannus. Gutman has obtained good results by searing the adjacent conjunctival vessels. In pannus crassus he touches the upper part of the granulation tissue lightly with the cautery. Cusner has done peridectomy in sixty cases in the quiet interval between attacks, and has not had a single relapse. He excises, down to the sclerotic, a sector of mucous and submucous tissue of a width of 3 mm. around the limbus. He corroborates the findings of Brueckner, mentioned above, that the vessels in the cornea do not become obliterated at the subsidence of the inflammation. The walls simply collapse and refill at the next relapse. Dickson (*Pract. Med. Series*, p. 1, 1911) exsects the pannus with scissors.

Casey Wood (*System of Oph. Operations*, Vol. I, 917) points out that there is a wide divergence of opinion among eye surgeons on the question whether special operative procedures directed against pannus are justifiable or not. MacCallan, for instance, believes there is no treatment for pannus, per se, the indication being to improve the lids as much as possible. In very severe cases of trachoma, the cure can

only be effected by replacement of the diseased tissue with cicatricial tissue. It is in these cases that pannus if often marked. It is, according to MacCallan, "frequently protective in nature as regards the nutrition of the cornea and should not be interfered with."

It is probable that a distinction should be drawn between "acute pannus," when invading vessels are rapidly advanced to convey much needed nutrition to newly formed ulcers, and what Beard calls "pertinacious vascularity of the superficial portions of the cornea." In the former case the new formed vessels have a definite office to perform. Coincident with an improvement in corneal nutrition their function ceases and they frequently shrivel to mere threads. If, however, they persist indefinitely and remain uninfluenced by treatment directed to the disease, the question of eradicating them by direct surgical attack should be seriously considered.

Furnari (*Ann. d'Oculist*, 1863. XLIX p. 272) was the first to advocate removal of a strip of conjunctiva surrounding the cornea as a means of combating pannus. A broad ring of circumcorneal conjunctiva extending from the cornea to within 3 mm. of the line where the conjunctiva is reflected from the globe to the inner surface of the lid, is dissected up. The subconjunctival tissue is dissected to expose the sclera and the vessels of the cornea are scarified. Finally, the sclera and ulcerated cornea are touched with a strong solution of silver nitrate. The indications for this operation as given by Furnari are as follows: (1) In membranous or fleshy panus. (2) In phlebectasiæ of the conjunctiva or cornea. (3) In simple vascular keratitis. (4) In interlamellar infiltrations of the cornea. (5) In corneal lesions attending entropion, ectropion and trichiasis. (6) In staphyloma of the cornea.

Agnew (quoted by Beard, *Ophthalmic Surgery*, p. 353) practised a similar method, and insisted on a thorough curettage of the episclera surrounding the cornea. The trunks of the corneal vessels were scratched or touched with glowing galvano-cautery where they crossed the limbus. At the dressings the conjunctiva was loosened and pushed back with a blunt instrument.

The operation of peridectomy is thus described by Fox (*Diseases of the Eye*, 1904, p. 122) who has been a most ardent advocate in America of this operation.

"The eyelids are held apart by the speculum and several instillations of cocaine made in order to anesthetize the conjunctiva. A fold of conjunctiva near the cornea is grasped by the fixation forceps and divided by scissors. For partial pannus a band of circumcorneal conjunctiva about 5 mm. wide is dissected on the side of the engorged

vessel. If the pannus be general, a complete circular zone must be cut away including the subconjunctival tissue to the sclera in order to form a dike of cicatrical tissue against the convergent vessels. In cases of pronounced pannus a circular incision of the corneal blood vessels by means of a Beer knife is necessary. The appearance shortly after the operation of peridectomy is often alarming, inasmuch as the vessels appear to get a fresh start and the pannus becomes thicker than before. The final outcome, however, is satisfactory. Atropia will have to be used to lessen the photophobia and pain."

Falta (loco cit.) cauterizes vascular loops with a galvano-cautery. He declares that curettage of the pannus leads to the formation of dense corneal scars.

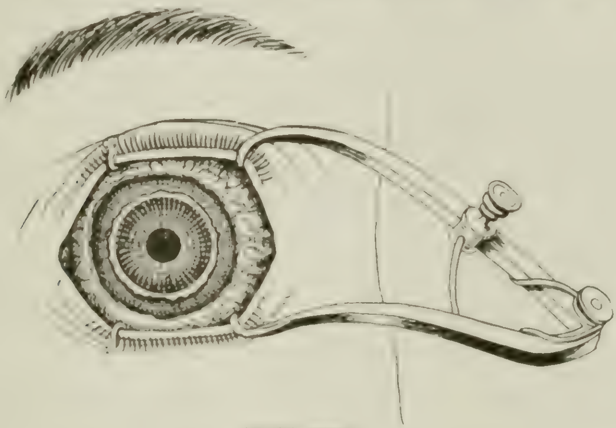
Boeckmann (*Zeitschr., für Augenheilk.*, II, 1899, p. 91) advocates the excision of an annulus of conjunctiva followed by vigorous scarification of the subconjunctival and episcleral tissue. The area is then dusted with iodoform. He aims to secure, through the formation of granulations, a scar tissue which will protect the cornea from further invasion of vessels.

Another method of operating in pannus has recently been described by William Primrose (*The Lancet*, April 21, 1906), of Glasgow. The point of a small knife is passed beneath the conjunctiva 2 or 3 mm. from the cornea in such a manner as to puncture subconjunctivally one of the large blood vessels. The knife is then withdrawn. By making the wound small and oblique external hemorrhage is avoided. The extravasated blood pressing upon the vessel walls arrests the subconjunctival bleeding. This mechanical action is increased by the formation of a coagulum, the fibrinous part of which shrinks. Primrose describes as follows the rationale of the method: "The extravasated blood acts as an irritant, probably chemical as well as mechanical, so a non-infective inflammation is set up which results in the absorption of the blood clot. This process acts as a counter-irritation to the inflammation of the corneal tissue and so tends to remove the seat of inflammation and the supply of blood from the diseased cornea to the clot, where the effects of the inflammation are comparatively trivial.

By the time the blood clot has disappeared, the blood vessels in the cornea affected by the operation have shriveled up and the cornea has regained much of its transparency. The whole pannus may be treated in this way at one time, or the operation may be repeated from time to time only a part of the pannus being treated each time. The latter is always advisable when the pannus is marked, as the inflammatory reaction is sometimes very severe and accompanied by a good deal of pain. Although the structures in the anterior part of the eye ball are

all more or less affected by the inflammation, this is easily controlled and subsides in a few days with the application of suitable remedies."

When pannus is the result of trachoma, the effect of Kuhnt's operation for the excision of the upper transitional fold or combined with the extirpation of the tarsus when involved, is usually followed by most gratifying results. The sliding conjunctival flap operation is another effective surgical method of curing pannus.—



Peridectomy.

(J. D. L.) See, also, **Trachoma**; as well as **Cornea, Vascularization of the,** p. 3521, Vol. V of this *Encyclopedia.*

Pannus carnosus. PANNUS CRASSUS. A form of the disease in which the cornea is extremely vascular and opaque and assumes a red, fleshy appearance.

Pannus eczematosus. A synonym of phlyctenular keratitis when it forms a pannus-like formation on the cornea.

Pannus, Granular. The form in which granulations form on the cornea resembling closely the similar deposit on and in the conjunctiva.

Pannus, Herpetic. Pannus due to continued herpetic eruption of the lids.

Pannus lenticularis. Lentigo.

Pannus leprosus. Pannus caused by leprosy of the conjunctiva.

Pannus lymphaticus. Same as *pannus phlyctenulosus.*

Pannus phlyctenulosus. Cloudiness and vascularity of the cornea induced by a phlyctenular inflammation.

Pannus rebellis. Pannus with occasional inflammatory exacerbations.

Pannus sarcomatosus. Same as *pannus carnosus.*

Pannus scrofulosus. A name for *pannus phlyctenulosus.*

Pannus siccus. Pannus in which the tendinous covering of the cornea becomes peculiarly dry, and with a silky gloss.

Pannus tenuis. A condition in which the blood-vessels are few and scattered and the cloudiness of the cornea is slight.

Pannus trachomatosus. Pannus caused by trachoma.

Pannus vasculosis. A name for *pannus crassus*, or *cornosus*.

Panophthalmitis. Suppurative choroiditis or uveitis. Infective uveitis. Metastatic chorioretinitis. Inflammation of all the structures of the eye. It is called *ectogenous* when due to trauma, perforating corneal ulcer, hernia of the iris—in other words to infection from without. It is *endogenous* in those (rare) cases in which the infective material is derived from the blood, lymph or other internal sources.

As most cases of diffuse, suppurative uveitis are due to injury the attention of the surgeon is, of course, directed to this important cause, whether it be operative or accidental. As even the mildest forms of the disease (circumscribed suppurative choroiditis, for example), are fraught with the gravest consequences to vision and generally progress until the eye is destroyed, it is important to use the most effective prophylactic measures we possess when danger threatens, as well as to begin treatment at the earliest stage of the infection.

In threatened infection of the intraocular contents from exogenous infection the path of infection should be disinfected at once with iodoform rods, or by means of intraocular injections of 25 per cent. argyrol, given once or twice daily. Iced compresses are always indicated and in proper instances blood-letting. A Credé poultice of collargol, applied to the eye at night, is often of decided benefit. Infected corneal or scleral wounds, operative and other, should be touched with the galvanocautery.

In all forms of infection from without we must not ignore the testimony of observers, like Woodruff, who find great benefit from deep, sub-conjunctival injections of mercury oxycyanide. Definite directions for the use of these valuable adjuncts will be found under **Subconjunctival injections** and in the list of drugs.

Pain sometimes is relieved by iced compresses and full doses of aspirin at night; occasionally, hypodermic injections of morphia are required.

In the milder forms of the disease inunctions of mercury with iodides internally, or large doses of sodium salicylate, certainly assist in checking the progress of the disease. More is to be expected of this treatment, also, in the localized infections and in those cases of metastasis where the invasion of the posterior chamber is not too virulent.

When, in spite of all treatment the disease grows worse, the pain more violent and the swelling of the lid and orbital tissues more pronounced enucleation of the globe is in order. If the edema of the

tissues and the other signs of the disease are very marked it is, perhaps, better to incise the cornea, apply hot fomentations and wait a day or so until the emptying of the intraocular abscess gives some relief before doing the complete excision. At the same time the Editor has frequently removed a panophthalmitic eyeball surrounded by a brawny infiltration and edematous lids with great relief to the patient and without any subsequent evidence of involvement of the brain cavity. Yet, it must be remembered that well-authenticated cases of postoperative meningitis are on record.

In the performance of an enucleation it is wise to avoid wounding the conjunctiva any more than is absolutely necessary; symblepharon or cicatricial bands in the conjunctival sac may demand an operation for their repair before an artificial eye can be worn with comfort.

For the *bacteriology* of panophtholmitis see p. 853, Vol. II of this *Encyclopedia*.

Among the earlier essays on the bacterial origin of the disease is that of Lutz (*Klin. Monatsbl. f. Augenheilk.*, July, 1910). The author reports thirteen cases of panophthalmitis of ectogenous origin. In seven cases the *pneumococcus* was the causative microbe, and four of these cases were post-operative, while the remaining three were due to injury, such as perforations by scissors, rupture from blow of fist, etc.

The remaining cases showed the bacillus subtilis in pure culture in four cases, and mixed with an anërobic bacillus in the others. R. R. James reviews (*Oph. Rev.,* March, 1911) the article.

Lutz has nothing to say about the pneumococcal cases. The subtilis infection gave a well-defined clinical form:—rapid development of panophthalmitis, with relatively trifling participation of the surroundings of the globe, no rise of temperature, and no constitutional disturbance save pain, but his paper is mainly concerned with the cases in which an anërobic bacillus was found, which number three.

The first case occurred in a child, and was due to a perforating wound brought about by the child falling and striking his head on a dirty doorscraper. Bacteriologically the following microbes were separated from this case:—(1) Aërobic. Xerosis bacillus; bacillus proteus; bacillus subtilis. (2) An anërobic bacillus. Mice and guinea pigs inoculated with fresh material died within 24 hours, and post mortem there was found extensive hemorrhagic edema of the subcutaneous tissues with some gaseous development and no pus formation. Smear preparations proved the presence of short Gram-positive bacilli, arranged in pairs without any chain or spore formation.

Aërobic cultures from the subcutaneous edema remained sterile,

while anërobic cultures on sugar agar gave rise to rapid development of gas, with turbidity of the culture medium.

Subcultures produced greyish-white colonies the size of the head of a pin, with an uneven surface, while bouillon became turbid, and milk underwent the "enteritidis" change.

Intra-muscular inoculation killed a guinea pig in 24 hours, while a rabbit inoculated subcutaneously survived; inoculation into the anterior chamber of another rabbit produced hypopyon keratitis, and inoculation of the vitreous produced a severe panophthalmitis, with intense chemosis, with lids swollen and of a board-like hardness.

Lutz looks upon the anërobic bacillus in this case as bacillus phlegmonis emphysematosæ.

Case 2 was due to injury by splinter of steel flying off a hammer. In this case the splinter, which was of a large size, was removed by the giant magnet through the wound of entrance; panophthalmitis developed, and the eye was enucleated by Prof. Haab under local anesthesia with eucain, novocain and cocain.

The socket was drained with iodoform gauze wicks. The bacteriological finding in this case was the bacillus phlegmonis emphysematosæ in pure culture.

Case 3 was due to a stone-breaking injury. The infection in this case was mixed, b. subtilis and a gas-forming organism of trifling virulence, as shown by the small amount of gas formed, and by the fact that all the animals inoculated from the sub-cultures survived. Microscopically the anërobic bacillus had the following properties. Gram-positive, oval spores, formed at the ends of the bacilli, trifling development of gas, and tendency to chain formation, and agrees with the microbe number 15 in Hibler's newest category of the anërobes.

Lutz discusses the question of enucleation in cases of panophthalmitis, and adduces weighty reasons to show why excision should not be performed in cases of pneumococcal and streptococcal infections, but he thinks that the matter is on a different footing in cases of subtilis and gaseous infections, and advises immediate excision, should the bacteriological report prove that either of these two microbes is the causative agents, and in this respect he is in complete accordance with the views of French surgeons such as Chaillons and Oreste, and also with those of the present reviewer, who has had two similar cases.

Lutz advises in cases of gaseous infection that after excision the socket be flushed out with permanganate solution, or hydrogen peroxide, and that a gauze drain be inserted.

Abe (*Ophthalmic Year-Book*, p. 273, 1909) has studied, by experiments upon the eyes of the rabbit, the production of *panophthalmitis*

from the bacteria taken from hay, grass, straw, moss, rice, dust, feces, etc. Of 23 kinds obtained from such sources, 17 produced panophthalmitis, when injected into the vitreous of the rabbit; although the subcutaneous injection did not cause suppuration, and panophthalmitis never followed rubbing them into a corneal wound. The bacillus subtilis, being common, is especially liable to be found in the eye after injury. But Abe concludes that panophthalmitis may be set up by many different bacteria. Benedetti reports a case in which he found the bacillus perfringens. Capolongo reports two cases in which the pneumococcus seemed to be the cause. In a case studied by Kuwabara the colon bacillus, with enormous capsule formation, was found. Ancona reports a case as due to the bacillus subtilis.

Wirtz found the tetanus bacillus in an eye eviscerated for panophthalmitis, following a ragged perforating wound of the cornea made with the lash of a whip. Kümmell reports a case of so-called spontaneous panophthalmitis and brings together a number of previously reported cases. In his case the condition followed *vaccination.* He thinks that in general such cases should be explained as metastatic, the source of infection being a minute pustule, probably produced by the white staphylococcus. Pagenstecher reports a case of ocular metastasis from a boil on the neck. Cultures showed staphylococci. The globe subsequently became greatly shrunken, although the cornea remained of normal size.

Kellermann reports a *tuberculous panophthalmitis* or probably a mixed infection following the puerperium. Kitamura reports, with microscopic observations, two cases of metastatic ophthalmitis. One occurred with a general streptococcus infection which proved fatal. The other followed a sinus thrombosis of otitic origin, the eye being enucleated several months later. Coover reports a case of ocular infection, in which the eye burst, following erysipelas in the nostril of the same side. Cosmetattos saw a case of bilateral metastatic ophthalmia, with epidemic cerebro-spinal meningitis. Light perception was lost in one eye in 10 days, and in the other in 2 weeks. In the latter a little vision was regained, and after iridectomy large objects could be perceived close to the eye.

For further consideration of *metastatic panophthalmitis* see p. 2146, Vol. III and p. 7672, Vol. X of this *Encyclopedia.*

Panoptic. Rendering everything visible; said of a stain which differentiates all the tissues of a specimen.

Panorama. 1. A complete or entire view; also, a picture representing a wide or general view, as of a tract of country. 2. A picture representing scenes too extended to be beheld at once, and so exhibited, part

at a time, by being unrolled and made to pass continuously before the spectator. 3. A cyclorama; in this sense also called circular panorama.

Panoramic. Pertaining to or of the nature of a panorama. *Panoramic camera,* a photographic camera, especially devised for the taking of panoramic views. The camera is caused to rotate by clockwork, or otherwise, the plate being at the same time automatically moved so that, as the lens is turned toward successive parts of the landscape, other parts of the plate are constantly exposed through an aperture in a mask in the camera, until, if desired, a complete revolution has been accomplished. A picture made with this apparatus differs from an ordinary picture in that it is not a simple view, such as is seen at a glance in nature, but such a view as would appear to the eye could it be directed on all sides simultaneously. Also called pantoscōpe, or pantoscopic camera. *Panoramic lens,* a wide-angled rectilinear lens; a lens capable of projecting views which include 90 per cent. or more of angular aperture.

Panoramic camera. A rotatable instrument employed to make cycloramic photographs.

Panoramic lens. A wide-angled lens.

Panottalmite. (It.) Panophthalmitis.

Pansement. (F.) Dressing.

Pansement à demeure. (F.) Permanent dressing.

Pansement ouvert. "Open" dressing, i. e., one that keeps the wound exposed to the air.

Pantachromatic. Entirely achromatic.

Pantankyloblepharon. General adhesion of the eyelids to the eyeball and to each other.

Pantometer. An instrument for measuring angles in any direction.

Pantopon. See **Omnopon.**

Pantoscope. Pantascope. 1. A form of lens including a very wide angle, devised especially for photographic use. 2. A panoramic camera. See, also, **Panoramic.**

Pantoscopic. Adapted to view both near and distant objects; a term applied to bifocal spectacles.

Pantoscopic camera. A panoramic camera.

Pantoscopic spectacles. Spectacles of which the lenses are so shaped as to have different focal lengths in the upper and lower parts, and which are thus adapted for the use of persons when viewing objects close at hand and at a distance. Also called *Franklin spectacles.* See, also, **Bifocal lens.**

Panum, Peter Ludwig. A celebrated Copenhagen physiologist, of

moderate importance in ophthalmology. Born at Ronne (on the Island of Bornholm) Dec. 19, 1820, son of a military surgeon, he studied chiefly at Copenhagen. For a time he was hospital physician in that city, then a naval surgeon in the Schleswig War, and, in 1850, a cholera physician in Bandholm. He subsequently abandoned private practice, and devoted himself to physiology and physiological chemistry. He lived and taught in a number of cities, chiefly in Copenhagen. His death occurred from rupture of the heart May 2, 1885.

Panum's only ophthalmic writings of importance consisted of a number of articles in Graefe's *Archiv*, entitled "Physiologische Untersuchungen ueber das Sehen mit zwei Augen."—(T. H. S.)

Paoli, Cesare. An Italian ophthalmologist. Born at Asisi in 1813; he received the degree of Doctor in Medicine at Pisa, where, it seems, he practised for a short time. Removing in 1839 to Florence, he there became (in 1849) professor of ophthalmology, a position which he filled for more than fifty years. He died in 1901.—(T. H. S.)

Paper, Lens. Very soft bibulous paper used for cleaning lenses.

Papers. CHARTÆ. "Papers" are pieces of absorbent paper that have been treated with medicinal substances. Only one is official in the U. S. P.—mustard paper, intended to be dipped into warm (not hot) water and applied to the skin as a rubefacient. In prescriptions papers are ordered by the square inch, thus: ℞ Chartæ sinapis, 2x3 inches. Dip into warm water and apply to the temple. ℞ Chartæ epispasticæ vel cantharidis, 2x3 inches. To be applied above the eyebrow until it blisters.

Papias Autolycus Laodicensis. An ophthalmologist of ancient Greco-Roman times, concerning whom we know almost nothing, except that he invented a prescription for the treatment of trichiasis. This prescription, which has been preserved by Archigenes, calls for mezereon mixed with frog's blood. With this combination the edge of the affected lid was lightly touched, after epilation, to hinder the return of the lashes.—(T. H. S.)

Papier moutarde. (F.) Mustard leaves.

Papilla. NERVE HEAD. OPTIC DISK. PAPILLA NERVI OPTICI. Intraocular end of the optic nerve. See p. 4031, Vol. VI of this *Encyclopedia;* also **Fundus oculi.**

Papilla, anomalies and diseases of the. Most of the rubries under this general heading have already been discussed in this *Encyclopedia.* See **Congenital anomalies**; and in particular the acquired conditions. They are, chiefly, *anemia of the nerve-head;* for which symptom see such captions as **Optic nerve, Atrophy of the**; as well as such others, as **Quinine amblyopia.**

Hemorrhages on the disk are generally a part of retinal bleedings; see p. 5800, Vol. VIII of this *Encyclopedia.*

Drusen of the nerve-head; see p. 4085, Vol. VI, and p. 2330, Vol. IV of this *Encyclopedia.*

Inflammation of the papilla is fully studied under **Optic neuritis;** also under **Papillitis,** and **Choked disc,** p. 2074, Vol. III of this *Encyclopedia.*

See *papillary tumors* under **Optic nerve, Tumors of the,** as well as under special **Optic** tumor headings.

Connective-tissue masses on the papilla. See p. 2924, Vol. IV of this *Encyclopedia.*

Hyperemia of the papilla is merely a symptom of many abnormal intra- and extraocular states. Prominent among these are the various forms of *papillitis; eyestrain; injuries of the eye,* and in many other conditions described under **Neurology of the eye.**

The treatment of this condition is of the underlying cause.

Calcareous deposits on the papilla. This condition is seen in degenerated globes, but is not common. Graefe and others have found and reported instances in which the body of the nerve was infiltrated with lime salts to such an extent that it could with difficulty be divided. As a rule, however, calcareous deposits occur anterior to the lamina cribrosa.

Colloid excrescences on the papilla. See p. 2326, Vol. IV of this *Encyclopedia.*

Hyaline bodies on the papilla. See p. 236, Vol. IV of this *Encyclopedia.*

Pigmentation of the papilla. See p. 2948, Vol. IV of this *Encyclopedia.*

Papilla del nervo ottico. (It.) Optic disc.

Papilla lachrymalis. The conical elevations on the upper and lower eyelids, at the inner canthus, containing the openings to the lachrymal canals. See p. 1042, Vol. II of this *Encyclopedia.* See, also, **Anatomy of the eye.**

Papilla nervi optici. Optic disk or nerve-head.

Papilla, Optic. See **Disc, Optic.**

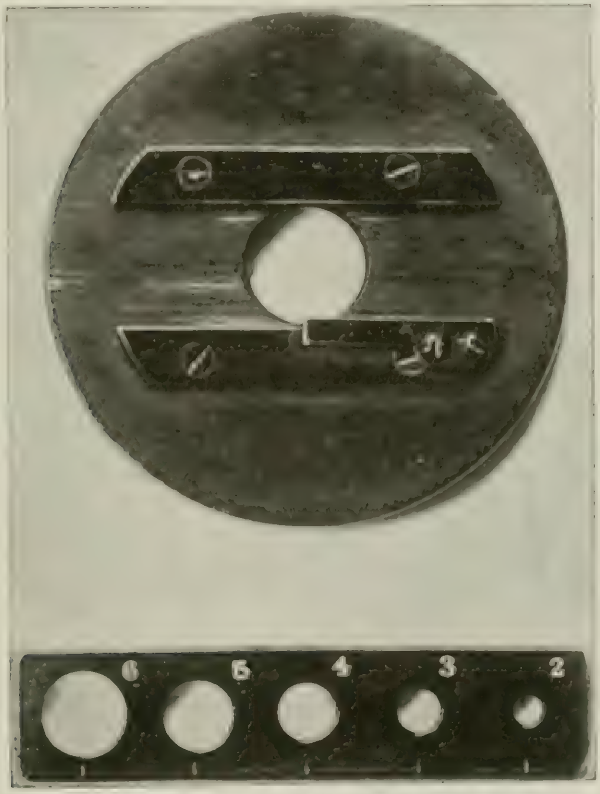
Papillary disc. A name given to a contrivance (see illustration on following page) for the correction of simple refractive errors.

Papilledema. PAPILLITIS. PAPILLŒDEMA. EDEMA OF THE OPTIC PAPILLA. CHOKED DISK. OPTIC NEURITIS. See **Choked disc** and **Optic neuritis,** under which headings the subject is fully discussed to the date of publication.

Reference may also be made here to certain aspects of the subject,

given under **Military surgery of the eye**; and to the recent experience of Walter H. Jessop and others.

The difficulty in the nomenclature of the various optic nerve swellings is discussed by Hardy (*Oph. Year-Book*, p. 228, 1916). For example, the prefix "albuminuric" is improper. Nephritic, renal, or



Mason's Papillary Disc for the Correction of Spheric Aberration.
(See caption on preceding page)

toxic neuritis and retinitis have been suggested as better. The author aligns himself with those who definitely discriminate between optic neuritis and choked disk, believing that papilledema is primarily a noninflammatory condition. The contentions embodied in the paper are: (1) That optic neuritis and choked disk are etiologically distinct entities; (2) that the assumption of a manifold pathogenesis of choked disk is probably incorrect; (3) that papilledema is primarily of mechanical origin, all the concomitant phenomena being accountable for on that basis; (4) that the inability to always distinguish clinically

between the two conditions does not necessarily imply a common origin or identical process; (5) that optic neuritis is primarily and essentially an inflammatory process, choked disk is primarily and essentially an edema and lymph stasis, the result of increased intracranial tension; (6) renal choked disk exemplified both processes, each with its separate pathogenesis, showing a lymph stasis with edema, also inflammatory changes.

A pure optic neuritis in renal diseases is a rather infrequent finding. Choked disk occurs most frequently in the relatively young, and is probably not reported more frequently for the reason that, it being a terminal symptom, the ophthalmologist is not consulted. Again, it is possible for papilledema to be present with good central vision, the patient, therefore, giving no heed to his ocular condition.

Jessop (*Ophthalmoscope*, December, 1915) calls attention to the large proportion (72 per cent. in 47 cases) of patients with gunshot injuries of the vault of the skull giving signs of papilledema. In most of his cases the swelling of the optic disc was slight, generally about 1 D., and seldom more than 2 D. or at most 3 D. Other ocular signs or symptoms were rarely present. Both discs were usually affected, sometimes one more than the other. The changes were chiefly on and in the close neighborhood of the disc, and acute in their onset. The papilla was pinkish in color, the edges of the disc were indistinct and blurred and the vessels were raised close to the edges.

In many cases there is a distinct, narrow, yellowish-white ring around the disc, having a blurred outline and evidently caused by edematous effusion. There may be a striation of the retina near the disc. If there is a marked physiologic cup, it may be partly or wholly filled up. The vision in most cases is not affected. The color-sense and the fields of vision are normal.

On relief of intracranial pressure the ophthalmoscopic signs subsided in five or six days, and no signs of any optic atrophy followed.

A case of rifle bullet wound of the left frontal region showing no signs of intracranial pressure except papilledema of right eye, 2 D., and left eye, 1 D., is described. Both fundi showed an edematous ring round the discs. Operation revealed depressed splintered bone with evacuation of half an ounce of pus from an intradural abscess. Patient recovered with vision of 6/6. It is advisable to watch the papilledema carefully in every case.

Among the numerous recent papers on the subject, Greeves' review of von Hippel's essay (*Centrabbl. f. die Ges. Ophthal. und ihre Grenzgeb.*, in the *Ophthalmoscope* for July, 1914) gives a résumé of important facts relating to papilledema. The writer states that papil-

ledema associated with intracranial disease is undoubtedly, in the great majority of cases, an indication of raised intracranial pressure, although the method by which the raised pressure acts is still a matter of dispute. Papilledema is, then, of great diagnostic importance, especially in the earlier stages, in which it is most essential to distinguish papilledema from optic neuritis.

Uhthoff regards a swelling under two dioptres in height as more likely to be a neuritis than a mechanical edema, but von Hippel thinks this distinction open to criticism. He points out that there must be an early stage in all cases of papilledema, in which the swelling is under two dioptres, and this is the very time when, as already indicated, it is most important to make a correct diagnosis.

In order to arrive at a diagnosis, attention must be paid to fine details of ophthalmoscopic appearance, to general symptoms, and, lastly, to the clinical course of the case.

As regards ophthalmoscopic appearance, Schieck believes the earliest phenomenon in papilledema to be a blurring of the centre of the papilla where the large vessels emerge, while Horsley, on the other hand, maintains that the swelling always begins in the upper nasal quadrant. von Hippel agrees with neither of these authorities. He states that the papilla has a definite mushroom-head (? upside-down) appearance, with raised edge and deep central cup, in the earliest stage.

As regards disturbance of function, in true papilledema it is rare to find anything beyond a slight increase in size of the blind spot, whereas, even in an early stage of neuritis, definite deterioration of vision is common.

General symptoms of intracranial pressure will, of course, render the diagnosis certain, but in their absence, increased swelling of the papilla, without a corresponding decrease of visual function, points to a papilledema.

The most difficult cases are those in which an optic neuritis is complicated by the presence of a papilledema.

In the late stages, when atrophy has set in, it is impossible to distinguish the two conditions by the ophthalmoscope. But in this case the differential diagnosis is of comparatively little importance, in so far as any possible improvement of vision by treatment is concerned.

Horsley lays great stress on his belief that the more marked changes in the papilla, if not necessarily the greater swelling, occur always on the same side as that on which the cranial lesion is situated. Uhthoff and Mohr's statistics, quoted by the writer, do not always bear this out.

The prognosis of cases upon which no operation is performed is

absolutely bad, whereas suitable operative treatment, if resorted to early, frequently results in full conservation of vision.

When possible, the disease must, of course, be radically removed, failing which a palliative operation must be performed. Of the various palliative procedures which have been advocated, viz., trephine puncture of the third ventricle, drainage or puncture of the lateral ventricles, and lumbar puncture, the first is the most generally satisfactory.

The operation of puncture of the third ventricle, establishing a communication between the ventricle and subdural space, has proved useful in certain cases, but cannot be said to be applicable to all.

No set rules can be given as to the most advantageous site for trephining. This must necessarily vary in different cases, but in the great majority it is necessary to incise the dura mater. Subcutaneous drainage of the ventricle may be combined with trephining. The therapeutic value of lumbar puncture is doubtful in cases of tumor. This procedure has, however, proved beneficial in meningitis cases.

The writer concludes by again insisting on the urgent need for operative interference in the early stages by laying stress on the readiness with which the condition yields to appropriate treatment.

Papille étranglée. (F.) Choked disc.

Papillitis. See **Papilledema,** as well as **Choked disc,** and **Optic neuritis,**

Alternating papillitis. George Coats (*Ophthalmic Review,* p. 233, Aug., 1914) has the following to say about the (unusual) case described by E. Raubitschek (*Klin. Monatsbl. f. Augenheilk.*, p. 457, 1914). It was peculiar from the alternating character of the papilledema and from its rapid retrogression. When the patient, a woman aged 52, first came under observation the right eye was in all respects normal. In the left there was marked papilledema, with much congestion of the vessels, many hemorrhages, and a swelling of 3 D. These changes underwent a speedy evolution; within a fortnight the swelling had disappeared, the papilla was very pale, and the vessels were much constricted. Vision 6/36. About a week after this the left disc began to become edematous, and in a few days marked choked disc had developed, which ran the same course as in the other eye. The heart was hypertrophied, the blood pressure much raised, and the urine contained albumen, which disappeared temporarily at least under treatment. The diagnosis nevertheless was granular atrophy of the kidneys.

It is perhaps questionable in this instance whether a predominant part is to be ascribed to arteriosclerosis as such, or to the nephritis. But in many cases the two conditions are so intertwined that a differentiation of their effects is impracticable. In a second case which the author reports there was a similar alternation of papilledema be-

tween the two papillæ, but at an interval of six months; in this instance arteriosclerosis seemed to be the more important factor. These observations seem to tell somewhat against Kampherstein's dictum that choked disc in nephritis is an indicator of an associated disease of the brain, or at least of heightened intracranial pressure. It is perhaps not difficult to understand how nephritis might lead to increased intracranial pressure, but it is not so easy to see why the resulting papilledema should be unilateral. The author somewhat vaguely refers to vascular changes, but, after all, a similar unilateral incidence is sometimes observed in cases of cerebral tumor.

Papillœdema. See **Papilledema.**

Papilloma, Ocular. This well known new growth is an epithelial tumor in which the cells cover finger-like processes or ridges of stroma. It includes *warts, cutaneous horns, polypi* and *condylomata.*

Papilloma of the conjunctiva. See p. 3048, and p. 3069, Vol. IV of this *Encyclopedia.* In addition to the description given there and on p. 3057, Vol. IV, it may be stated that in Freytag's review of the literature (*Archiv f. Ophthalm.*, p. 367, Vol. 90) papilloma was observed on the ocular conjunctiva in 6 cases, limbus 11, semilunar fold and caruncle 10, conjunctiva of the upper lid 3, lachrymal sac 1. Although papilloma generally is a benign tumor, occasionally a transition into *carcinoma* occurs, as shown in 4 cases. There were relapses after excision in 12 out of 34 cases.

Papilloma of the cornea. See p. 3427, Vol. V of this *Encyclopedia.*

The *limbus corneæ* is a favorite seat of these tumors. In the case of Piccaluga (*Arch. di Ottalmologià*, p. 462, Vol. 21, 1914) the patient, a man of 63 years, came in 1905, on account of a small papillary angioma of the bulbar conjunctiva near the inner side of the limbus. This was removed. In 1911 the eye was enucleated on account of a tumor which had developed at the site of the growth previously removed. This was diagnosed clinically as papillary epithelioma, but histologically proved to be a papilloma. Three months later the orbit was occupied by a large epithelioma, and although the orbit was exenterated the patient died in January of the following year from extension to the cranial cavity.

During the enucleation in 1911 a small independent growth was found behind the caruncle, and the author believes the epithelioma and papilloma to have developed independently of one another.

Contino (*Archiv f. Augenheilk.*, April, 1911) believes that there are at least *two distinct varieties* of these limbal tumors. The first he describes as small papillomata with massive proliferation of epithelium and small connective tissue papillæ. They are benign tumors, small.

well-defined, rarely lobulated, but the surface is covered with small excrescences. There is usually hyperemia of the surrounding conjunctiva. The condition is painless. There is some resemblance to pterygium and phlyctenule, and it may develop from the head of the former.

Second, papillomata where connective tissue proliferation is equal to that of the epithelium. The surface is covered with large excrescences; its edges ill-defined, gradually passing into the surrounding epithelium. There is little or no hyperemia of the conjunctiva. These growths have the character of true epitheliomata.

In the early stage it is difficult to distinguish these growths from commencing epithelioma. An epithelioma is more fixed to the cornea, and tends to ulcerate, which a papilloma does not. Enlargement of the neighboring lymphatic glands is of no value, as it is only a late sign when diagnosis is beyond question. He emphasizes the importance of thorough clinical and microscopical investigation. As to the origin of these growths, Contino does not believe that they are inflammatory, and due to an infective process. When there is hyperemia, it is due to mechanical irritation of the growth. The symptoms and course are entirely against the inflammatory theory. Bacteriological examination was always negative. He believes that papilloma is a true new growth, which, starting in a benign way, may become malignant. Possibly, the cause may be a congenital anomaly of the cornea, or it may result from trauma, giving rise to irregular growth of tissue. The limbus in the ocular fissure is the spot usually affected, and external irritation may therefore be a factor, especially as the growth is met with in people who live out-of-doors, as farmers and laborers. Four cases only have been recorded in women.

Prognosis is favorable so far as preservation of the eye is concerned, if the growth is not too extensive, and does not invade the cornea too deeply.

Treatment consists of total excision of the growth, starting with the corneal part. After removal, the wound should be thoroughly treated with the thermo-cautery. The growth should be dissected off in the same way as a pterygium. If the cornea is so involved that sight is destroyed, the eye should be enucleated. Exenteration had to be performed in one of Contino's cases where there was recurrence.

O. Valli (*Ophthalmic Literature,* Feb., 1917, review of *Annali di Ottalm.,* Vol. 44, p. 775) records one of these tumors in a man of 67 years. The tumor, which was said to have existed for ten years, was of a grayish-red color, and occupied the *sclero-corneal limbus* in its complete circumference, extending more or less widely on to the

bulbar conjunctiva and on to the cornea. Its maximum measurements varied from 10 mm. below to 12 mm. above, the greater part of this diameter in each case being on the conjunctiva. It was elevated two or two and one-half mm. from the level of the eyeball. The part of the cornea not invaded by the tumor was cloudy and edematous. The tumor was dissected free from the eyeball, and the eye did fairly well for several months, after which the patient returned with a recurrence at the upper part of the limbus and on the cornea. This new tumor was removed, but the further history of the patient is not given.

The papillary character of the tumor was well marked in microscopic sections. An interesting feature of this tumor and of the next one described was the finding, in the center of dense proliferations of epithelium, of cornified cells constituting true epithelial pearls. Worthy of note also were numerous alterations of a retrogressive character, which were found in the epithelial elements, especially in the middle and superficial layers.

In the second case, that of a woman of 56 years, the history dated back six years. The tumor was astride the limbus, extending on to both the conjunctiva and cornea, having a maximum diameter of 10 mm., and an elevation of 0.8 to 1 mm. Operation was done in two sittings, at first removing that part of the tumor which was upon the sclera, and one week later doing galvanocautery of the pannus-like extension on to the cornea. Complete cure followed. In the third case the patient was 54 years of age, and the affection was of more than three years' duration. The tumor was a smaller one, measuring about 5 by 2 mm., by 3 mm. in elevation. Surgical removal and thermocautery resulted in complete cure.

The microscopic structure of all three tumors was very similar. Each was made up of two distinct layers, a deep layer of new-formed connective tissue elevated into papillæ, and a superficial layer formed of the normal epithelium, in which, however, various degenerative processes had taken place. The third tumor differed from the first two by being pedunculated and much more elevated, with long papillæ. In spite of the presence of degenerative cellular elements similar to those found in epitheliomata, these new formations are to be regarded as benign tumors.

Papilloma of eyelids. WART OF THE LID SKIN. PALPEBRAL HORNS. See p. 2534, Vol. V, as well as p. 5019, Vol. VII of this *Encyclopedia*.

Papilloma of the iris. This very rare tumor has been observed by J. Schneider and by Owen. A case reported by Colsmann is regarded by de Wecker as a nevus of the iris.

A number of *mixed papillomatous tumors* of the eye are also de-

scribed in the literature. For instance see the *Roy. Lond. Oph. Hosp. Reports*, Vol. 18, p. 3, for an account of a papilloma with sebaceous adenoma of the caruncle. See, also, **Papillosarcoma.**

Papilloretinitis. NEURORETINITIS. PAPILLEDEMA. Inflammation of the retina as well as the optic nerve.

Papillosarcoma. A mixed neoplasm composed, histologically speaking, of sarcomatous and papillomatous elements. For example, Thibert and Dutois (*Scalpel*, p. 572, No. 34, 1913) describe such a tumor affecting the external eye, and the good results obtained by radiotherapy.

Pappenheim, Samuel Moritz. A well known German physiologist, of some importance in ophthalmology because of his "*Die Specielle Gewebelehre des Auges, mit Rücksicht auf Entwicklungsgeschichte und Augenpraxis*" (Breslau, 1842). Born at Breslau, April 8, 1811, he graduated there in medicine in 1835. He practised for a time in Breslau, became assistant to Purkinje, and wrote a considerable number of valuable books and articles on subjects connected with physiology. He soon, however, became insane, and was, for a time, confined in a lunatic asylum. Discharged as cured, he studied again in Paris, and received in 1847 the grand prize from the Academy of Sciences. For the next ten years he disappeared from view, being engaged in America in extensive investigations into the numerous Indian languages. He was found by friends in Havana, sick from yellow fever. When he had recovered, he was sent back to Germany, where, in 1861, he settled in Berlin. Here he led a peculiar life, was supported by his relatives, spent the most of his time in libraries, but found sufficient leisure for numerous quarrels, and at length died in a hospital Feb. 10, 1882.

He was a brilliant man, but paid the penalty of overwork.—(T. H. S.)

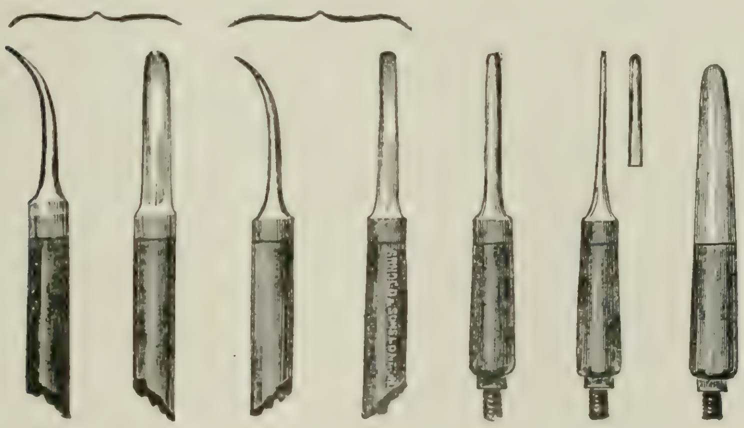
Papula. An old term for a nodule on the ocular conjunctiva.

Papular conjunctivitis. SYPHILITIC CONJUNCTIVITIS. There can be no doubt but that occasionally the conjunctiva shows, like the skin, a secondary syphilitic rash. A few such cases have been recorded. Schreiber reports that of a man aged 21 who had eroded patches both on the genitals and conjunctivæ. It was at first regarded as phlyctenular but under anti-luetic remedies the efflorescence and patches quickly disappeared.

Paquelin cautery. The so-called thermo-cautery; an apparatus founded on the property possessed by platinum, when heated red-hot, of remaining incandescent as long as the vapor of a hydrocarbon is projected upon it. A hollow piece of platinum, varying in shape

according to the purpose in view, is attached to a tube connected with a reservoir of benzin, the vapor of which is pumped into the hollow of the piece of platinum (previously heated in the flame of a spirit-lamp) by means of a hand-bulb.

This form of cautery is an ingenious device but it is difficult to keep the point at an even temperature, and for this reason alone it is inferior to the galvano-cautery in most ophthalmic cases. Another fault is that in using the instrument the hand is too far from the eye; nor is it as delicate an instrument as the electro-cautery. A variety of terminals has been devised, and the latest models of this instrument are greatly improved. Its advocates claim that the heat generated is more penetrating and beneficial than the other forms of cautery.



Thermo-Cautery (Paquelin) Points.

Paraamidobenzoic-acid ethylester. See **Anesthesin,** p. 459, Vol. I of this *Encyclopedia.*

Parablepsia. PARABLEPSIS. False or perverted vision.

Parabolic illuminator. A cylinder of glass one end of which is ground in the form of a paraboloid. The top of the paraboloid is then hollowed out so that the totally reflected rays from the paraboloid pass without refraction toward the focus of the paraboloid. A central disc is used to cut off the rays of moderate angle. This illuminator is used mostly for dark-ground illumination.

Parabolic lens. A lens of the shape of a paraboloid; or whose surface is generated by the rotation of a parabolic curve upon its axis.

Parabolic mirror. A mirror, every section of which through the principal axis cuts the surfaces in a parabola.

Paraboloid. A solid whose surface is generated through rotation of a parabola upon its axis. See, also, **Astigmatism.**

Paracentesis in eye diseases. PARACENTESIS OF THE CORNEA.

The main indications for this operation are to relieve acute pain and to permit the better action of iridoplegics and cycloplegics in iritis and irido-cyclitis; and to precede iridectomy in some acute cases of glaucoma, in which general anesthesia is contraindicated and in which there is a question of the performance of an iridectomy. It is also of value in some rare instances in which it would not be wise, for some reason or other, immediately to attempt to remove some gross form of mechanical pressure upon the intraocular lymph circulation, as in dislocation of the crystalline lens; and in threatened perforation of a corneal ulcer. By some, it has been used tentatively (and, of course, most judiciously) as an adjunct to massage in cases of intraocular embolism and thrombosis. It forms a part of the surgical treatment of keratoconus. Very rarely, indeed, it has been used to advantage for the removal of blood clots situated within the anterior chamber.

For a long period of time the operation has existed "in the domain of ocular surgery." It has been practised for a long time in China and Japan. In 1698, Nuck recommended it formally. He penetrated the central portion of the cornea with a fine trocar, which he plunged into the anterior chamber.

Sperino states that "sur un nombre immense d'opérations faites à la clinique de Turin et dans ma pratique privée, je n'ai jamais observé la suppuration de la plaie."

His views, with the opinions of others for and against its use, are all ably and succinctly given in the same book.

Rivaud-Landrau (*Congrès periodique d'Ophtalmologie*, 1862, p. 155) endorses Sperino's views and methods.

In the first volume of Monteath's translation of Weller's Manual (*A Manual of the Diseases of the Human Eye*, (English Translation), 1821, p. 225), we find the interesting editorial avowal that "The English now employ the evacuation of the aqueous humor, by means of a needle, very commonly, in inflammation of the eye."

In confirmation of this, it will be found that as late as 1840, Mackenzie (*A Practical Treatise on Diseases of the Eye*, American Edition, 1883, p. 410), Middlemore (*A Treatise on the Diseases of the Eye and its Appendages*, 1835, Vol. I., pp. 462-463), and Tyrrell (*A Practical Work on the Diseases of the Eye*, 1840, Vol. I., p. 236) made use of the method.

Wardrop has written extensively upon its usefulness. He performed it with either a narrow cataract knife introduced into the anterior

chamber near the corneal margin with its flat surface held parallel to the plane of the iris. He states that when the desired depth has been reached, the instrument is slightly turned upon its axis to facilitate the escape of the fluid. It should not be allowed to touch the iris. He made use of the procedure as an auxiliary treatment in all cases of hypopyon.

Lawrence practised it without any injury to the intraocular structures.

Macgregor (*A Treatise on the Diseases of the Eye*, American Edition by Hays, 1847, p. 378) states that "It is to be regretted that this operation is not more frequently performed; for I am convinced that many persons have lost their sight from rupture of the cornea taking place in front of the pupil, which a timely and judicious performance of this operation might have prevented." Both Mueller and Langenbach thought well of it; while Vetch says that the "testimony which I have to offer on this subject, goes more to establish the safety than the expediency of the operation." Benedict and Rosas have used it in iritis; the latter injuriously so. Carel (*Thèse de Paris*, 1872) and Diaz-Albertini (*Thèse de Paris*, 1856) speak of its employment in the treatment of hypopyon and perforating ulcers of the cornea.

The procedure is made as follows: General anesthesia is necessary only with children, and in non-contraindicated adult patients who are greatly depressed and suffering from intensely inflamed and hypersensitive eyes. After thorough cleansing of the parts, the eyelids are gently separated. This is best done by the fingers of a competent assistant. The incision, which is generally made with a narrow, bent keratome, or in some cases in which the anterior chamber is shallow, with a narrow lance knife, must be situated to the very best advantage in each individual case. Interference with the iris and the lens capsule should be avoided during the procedure. When the blade of the cutting instrument has been gotten to its proper position, it is tilted slightly to one side, so as to slowly evacuate the anterior chamber of its liquid and solid contents. The knife is then quietly withdrawn, care being taken to keep the patient still during this part of the procedure, which, as a rule, is found by some to be quite painful. The same deliberation and quietude of action is required if the lance knife is used. In order to remove any remaining material which should be taken out, a pair of fine cystectomy forceps or a flat spatula carefully introduced, may be necessary. As a rule, flushing of the chambers with a warm normal solution of salt through a bulb syringe, will accomplish the same purpose. Should the iris become prolapsed, which

is not very probable if the procedure be judiciously done, it can be replaced, or, in most cases, better, excised.

In case of sloughing ulcer of the cornea, after analgization of the conjunctival sac with cocaine, the eyelids are separated by a stop speculum (although its use is by no means necessary in many instances). This done, a Beer knife, or preferably, a knife needle, is passed through the cornea at the peripheral margin of the ulcerous area. The moment that the anterior chamber has been well entered, the breadth of the blade is carried across the incision, thus making an opening through which the contents of the anterior and the posterior chambers are allowed to make exit. Just as before, care must be taken not to injure the iris or the lens capsule. Atropine should be instilled, the operation field cleansed, and the eyeball covered by a protective bandage. Hot stupes can be applied directly over the bandage. Incarceration of the iris in the corneal wound must be guarded against: For this purpose, in measure, the writer makes use of atropine. According to some surgeons, it may be well in some cases to employ eserine so as to keep the iris tissue tense in order to prevent its prolapse into the wound. If the wound, however, be made oblique, there is but little danger of such incarceration.

The accompanying sketch gives a fair illustration of the method as pursued and depicted by Stellwag.

Abadie (*Traité des Maladies des Yeux*, 1884, I. p. 244) also gives an accurate and graphic account of the method in every detail, which is worth careful perusal.

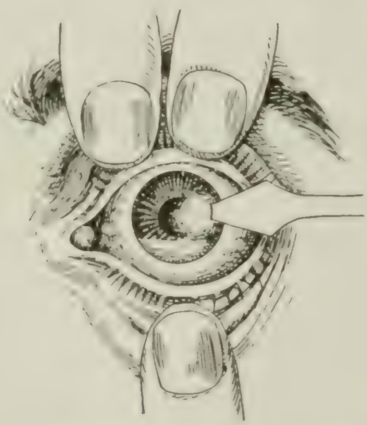
In the performance of paracentesis for corneal ulcer, Schell (*A Manual of Ophthalmic Practice*, 1881, p. 60) gives preference to the introduction of the needle through the corneo-scleral ring in such a way that the iris and the lens cannot be wounded.

Todd (*The Ophthalmic Record*, April, 1908, p. 180) has devised a modification of Wordsworth's cautery instrument. It consists of a handle and shank with a copper ball at the end of the latter, which has a platinum point extending from it at an angle. The copper ball holds the heat so that the point is sufficiently heated to cauterize the cornea for a period of several minutes' time.

Veasey (*Therapeutic Gazette*, 15th July, 1897) tells us that among "the more severe remedies at our disposal," should we be unable to check the progress of the ulcer, is the actual cautery, "and in a few cases does the proper use of it fail to prevent the further extension of the disease."

Treatment by means of the thermocautery has been carefully considered by Teleneff (*Vestnik oftalmologii*, XXXIV., 1907, p. 271).

In cases of slowly-healing injuries to the cornea, in which the endothelial layer of the membrane is pressed outward in the form of a minute hernia, Colburn (*Clinical Lectures on Diseases of the Eye*, 1902, p. 208) practices paracentesis of the cornea to lower tension of the eyeball. "The aqueous should be drawn out through the pericornea, thus allowing the hernia to recede and the ulcer to close up." He believes that the use of the galvano-cautery may be required to stimulate the process of repair. He enters the anterior chamber to the scleral side of the corneal junction. The instrument, which may be either a paracentesis needle, a bistoury, or a Graefe knife, must be directed in the plane of the iris. When the chamber is entered, the instrument must be rotated just enough to allow the aqueous humor to slowly escape, and should be withdrawn before it is touched by the iris.



Paracentesis of the Cornea. (Stellwag.)

Bert Ellis makes repeated use of the method in cases of impending perforation of the membrane.

Fuchs (*Lehrbuch der Augenheilkunde*, 1903, p. 181) considers paracenthesis of the cornea a valuable early aid in the prevention of threatened ulcerous rupture of the cornea. He performs it with either a lance knife or a von Graefe cataract knife. The puncture is made about two to three millimeters in length, the lips of the wound being carefully set into proper relationship by the aid of a Daviel's spoon.

Haberkamp has devised an extremely radical procedure for the relief of the agonizing pain of fulminating glaucoma in which enucleation is deemed essential. This operation in the hands of one who is unskilled in the use of the cautery, would be, in Beard's opinion, (in which the writer thoroughly concurs), "a delicate undertaking, as

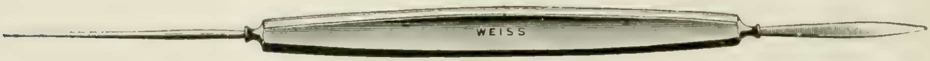
overheating of the aqueous, with consequent injury to the iris and the crystalline could easily be brought about.''

The method consists in a paracentesis of the anterior chamber by galvano-puncture. As the healing of the wound is slow, a prolongation of the effect from that which would be obtained from an ordinary paracentesis, can be gotten.—(P. A. C.)

Paracentesis at the thinnest part of the cornea to forestall and perhaps prevent ulcerative perforation of the cornea in spreading ulcer was first advised by Meyer.

Paracentesis cornea in glaucoma is described on p. 5480, Vol. VII of this *Encyclopedia.*

The same procedure in *retinal embolism* has been employed since the days of Graefe (1859), the idea being to reduce suddenly the intraocular tension and so increase the lumen of the obstructed vessel, in the hope that the plug may be shifted towards the periphery—generally a vain hope.



Lang's Paracentesis Needle.

Denig (*Pract. Med. Series*, Eye, p. 100, 1909) has *in uveal diseases* done *corneal paracentesis*, opening the anterior chamber at the limbus with a small keratome and allowing the aqueous to escape, in 10 cases. Four were cases of interstitial keratitis, 3 of iritis, 2 of chorioretinitis with vitreous opacities, 1 of postoperative cyclitis, and 1 of diabetic neuroretinitis. The operation was followed in most cases by an improvement in the symptoms.

E. A. Dorrell (*Trans. Oph. Soc. U. K.*, p. 49, 31, 1911) has devised a special paracentesis needle for *preparation of vaccines from the aqueous humor.*

Paracentesis of the posterior chamber, or posterior sclerotomy, is described on p. 5549, Vol. VII of this *Encyclopedia.*

Paracentral. Around or just outside the center, as a paracentral scotoma.

Parachroia. Abnormality of coloration.

Parachroma. (L.) Color-blindness.

Parachroma lapidis infernalis. Argyria or staining with silver salts.

Parachroma leucosis. Albinism.

Parachromatism. Color-blindness; incorrect perception of colors.

Parachromatoblepsia. (L.) An old name for color-blindness.

Parachromatopsia. Color-blindness.

Parachromatosis. Same as *parachromatism.*

Paradioxybenzene. See **Hydroquinone,** p. 6086, Vol. VIII of this *Encyclopedia.*

Paradis, Theresa von. A celebrated blind vocalist of the 18th century. She is said to have lost her sight from fright when a mere child. At the age of 7 she began to study music, and, when only 11 years old, sang the "Stabat Mater" before the Empress Queen, Maria Theresa. The result of this performance was a pension for life. She was also an excellent player on the organ and pianoforte. She invented a system of embossing musical compositions, which was of very much service in her career, but the method has, most unfortunately, been lost. The date of her death is not procurable.—(T. H. S.)

Paradoxic pupil. It has long been noticed that occasionally (in grave lesions of the central nervous system) the pupil acts in quite a different fashion than usual, *e. g.*, dilating in accommodation and on exposure to light, contracting in the dark and when the patient looks in the distance.

Deutschmann (*Beiträge zur Augenheilk.*, part 75, 1909) briefly summarizes the varieties of paradoxic pupil reactions, as described by Piltz in the *Neurologische Centralblatt* for 1902.

(1) The paradoxical accommodation reaction. (2) The apparent paradoxical light reaction. (3) The true paradoxical light reaction.

He goes on to say that the paradoxical accommodation reaction is frequently found in functional disorders of the central nervous system, that the apparent paradoxical light reaction is only observed in cases where iridectomy has been performed, and that the true light reaction is a very rare occurrence, and after excluding all known sources of error, such as the reaction due to warmth, to hippus, to sympathetic reaction, and to orbicularis reaction, the only known cases are those of (1) Morselli, in paralytic dementia; (2) Bechterew, in cerebral syphilis; (3) Leitz, in tuberculous meningitis; (4) Silex, in shock after accidents; (5) Deutschmann, in syphilitic optic atrophy; and that it almost without exception indicates a severe organic disease of the central nervous system.

Paraffin. Paraffin wax. Ceresin. A waxy, white hydrocarbon distilled from wood or coal. There are several varieties, all useful as excipients, emollients and as other agencies in ophthalmic practice.

Hard paraffin is a fat-like substance; *soft* paraffin, a petroleum jelly or vaseline or petrolatum, a yellowish, butter-like compound, while *liquid* paraffin is an oily liquid or paraffin oil.

C. V. Pratt (*Ophthalmology*, Jan., 1908) describes the use of *paraffin spheres* as an adjunct to simple enucleation. Paraffin, with a melt-

ing point of about 60° C., is filtered through ordinary filter paper into large test tubes. These are sterilized by steam under pressure. When the tubes are cool, the glass is heated so that the paraffin can be removed as a solid rod. This is placed in a warm, bichlorid solution and then cut into pieces and rolled into spheres about 2 cm. in diameter. To prevent contamination, rubber gloves should be worn while handling the paraffin. The spheres are preserved in a weak solution of bichlorid.

In the operation the conjunctiva is divided close to the limbus and dissected backward beyond the insertion of the recti muscles. These are picked up on a strabismus hook and separated from the surrounding tissue. Before dividing the tendons from their insertion in the sclera, each is caught by a small clamp. The writer uses four Halsted hemostats, known as the "mosquito" pattern. These prevent retraction of the muscles and the possibility of losing them. After dividing the tendons close to their insertions, the globe is enucleated in the usual manner. A paraffin ball is then dipped in sterile water to remove the bichlorid and cut, if necessary, to the proper size. The ball is seized with a pair of ordinary forceps and placed in Tenon's capsule. An elaborate introducer is entirely unnecessary.

The superior rectus is sutured to the inferior by a mattress or "U" suture and the two lateral recti in a similar manner. A slender, full-curve needle threaded with No. 00 chromacized catgut should be used. Large needles tear the tendon unnecessarily and the plain catgut is too rapidly absorbed. To prevent the muscle loops from slipping back over the ball and to give a common point of insertion, an additional suture is placed so as to include each muscle at the crossing of the two loops. Tenon's capsule is closed by a catgut purse-string suture. This relieves the tension of the muscle sutures, covers the ball with an extra layer of tissue, and prevents the latter from slipping out between the muscles. The conjunctiva is then closed with a purse-string, making, in all, 3 layers.

Care must be taken during the operation not to puncture the tendons unnecessarily, as each needle puncture causes the fibers to separate and a possible cutting through of the sutures. In the adult a ball 2 cm. in diameter will be found the most suitable size. After the enucleation the hemorrhage may be rather free, but the insertion of the paraffin checks this. No irrigation is used during the operation. A firm gauze dressing is placed over the eye. This is changed daily for the next 4 or 5 days and then discontinued. The pressure bandage has been found to lessen the subsequent chemosis. The reaction following the operation is about the same as after an evisceration. Chemosis, as a rule, lasts about a week, but may in exceptional cases continue longer.

One patient was discharged from the hospital with no chemosis on the fifth day.

The advantages claimed by the writer for the paraffin spheres over those of glass, metal, etc., are: 1. The spheres are easily made and are inexpensive. 2. They are not likely to be broken as those of glass. 3. Paraffin causes less irritation than any other material; therefore, is less likely to be extruded. 4. Paraffin is soon surrounded by a fibrous capsule, and is firmly held in place by connective tissue downgrowths.

An inquiry into the causes of failure of the paraffin to remain in Tenon's capsule suggests the following: 1. The use of the prothesis in cases not suitable, as in panophthalmitis or infected wounds. 2. The use of too large a ball, thus causing too much tension on the sutures. In a phthisis bulbi or in a child, a small sphere must be substituted for the globe. 3. Improper closure of the wound, thus leaving space for the globe to come out. 4. In cutting the optic nerve, the tissue in the back part of the orbit may be injured, thus allowing paraffin to work its way backward. 5. The use of soft paraffin. This will become warm and have a tendency to change its shape and wander about in the orbit. 6. Lack of asepsis, either in preparing the sphere or during the operation. The face and field of operation must be well covered by gauze, as the contact of the sutures with the skin, hair, or ether cone may spoil the effect of the operation.

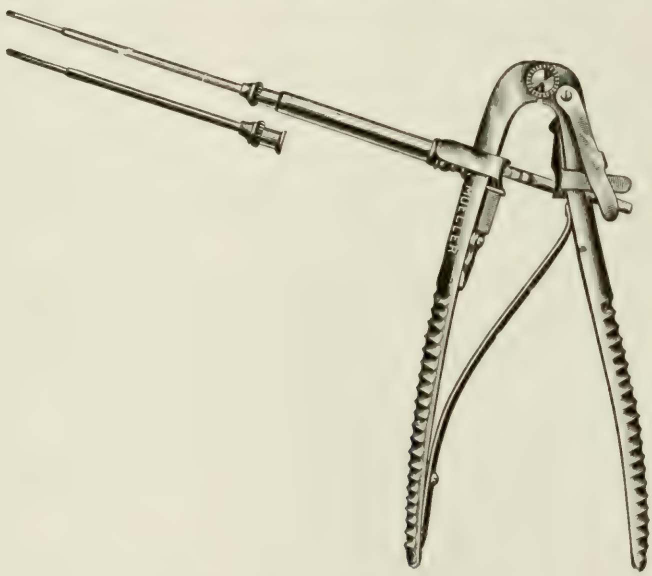
Paraffin-imbedding. See p. 6907, Vol. IX of this *Encyclopedia*.

Paraffin injections. Various paraffin and gelatin mixtures, as well as several varieties and combinations of these agents, are occasionally employed as subcutaneous and submucous injections in ophthalmic surgery. Their usefulness is mostly confined to supplying defects in the osseous structures of the orbit or in the neighboring facial bones; in filling the lachrymal sac, so as to outline it, prior to removal; for the relief of "saddle-nose," that a pince-nez glass may be worn and, occasionally, after enucleation and orbital exenteration, to assist in the fitting and wearing of a prothesis.

Gersuny (*Zeitschr. f. Heilk.*, 1900, Vol. 1, Part 9) was the first to employ this method and to give his experience of these injections on the bodily tissues. The injected material acts immediately by filling a void and eventually by stimulating cell growth, especially of connective tissue, so that a permanent (cartilage-like) increase in the volume of the parts is brought about.

A stout hypodermic syringe or, better, one of special construction may be used and any of the agents mentioned injected. White vaseline with a melting point of about 40 degrees C., is recommended by Elschnig. This is carefully sterilized, warmed in a water-bath and under

the most careful aseptic precautions, the syringe point is introduced down to the periosteum. The piston is then withdrawn a little to make sure that the terminal has not entered and is not lying in a bloodvessel. If no blood is withdrawn the body of the syringe is removed from the point and filled with the warmed, semi-liquid vaselin. The assistant now presses with his forefingers on either side of the area to be injected. About half the barrel of the vaselin is now injected, the needle-point extracted, the finger placed over the wound of entrance and the part gently massaged, to distribute the vaselin as desired. Then the parts



Beck-Mueller Paraffin Injector.

are sprayed with ether, to cool them off and harden the vaseline, sticking plaster is placed on the wound, and the assistant's fingers are removed for the first time. The injected area is red and sensitive for a week or ten days. The operation may be repeated in about six weeks, if needed.

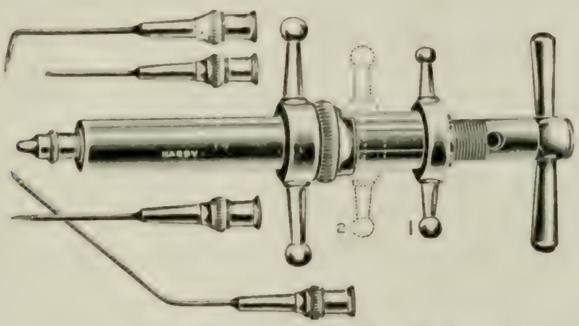
Injections into the soft tissues of the lid and orbit are objectionable. They do not answer any good purpose and the reaction is frequently dangerous.

For injecting the lachrymal sac, many instruments have been devised. Whatever syringe is used one should beware of employing force, it matters not what agent is used. Spermaceti (Valude), iodide of starch (C. R. Holmes), paraffin whose melting point is 110 to 120 degrees F. (Wilder), various forms of gelatine (colored or plain),

dental plaster (Fullenwider), or the low melting point paraffin mixtures recommended by Gersuny, von Pflugk, and others have all been successfully employed.

Other powerful syringes besides those already mentioned are Beck's and Broeckaert's. The illustrations fully demonstrate their modus operandi.

The difficulties attendant upon the injection of solid and semi-solid paraffin and gelatin mixtures is overcome in Pflugk's (*Deutsch Med. Wochenschr.*, No. 23, 1902) injection apparatus. He uses it for mixtures whose melting point is not below 42° C. As shown in the figure a strong syringe is surrounded by a water-coil carrying fluid sufficiently hot to render the paraffin liquid or semi-solid. The needle 25 mm. long is fitted to the barrel by a bayonet joint. The water flowing



Broeckaert's Paraffin Injector.

through the jacket should be between 50 and 60 degrees C. The material should be injected slowly and steadily, without strong pressure and only a few drops at a time, so as to give time for its hardening in situ. The inventor advises that not more than 20 drops be injected at one sitting. If used in this way the little operation is entirely without danger of embolism or other untoward accidents.

The *dangers of paraffin injections* into and in the neighborhood of the orbit have been pointed out by a number of observers. Loss of vision following this treatment for saddle-nose has been several times reported--probably due to embolism of the ophthalmic or retinal arteries, or to thrombosis of the corresponding veins.

Mintz (*Centralbl. f. Chirurgie*, Jan.. 14, 1909) reports severe pain in the left eye a few minutes after the injection, followed shortly afterwards by complete blindness, exophthalmos and oculomuscular paralyses.

Zahn (*Klin. f. Monatsbl. f. Augenheilk.*, March, 1910) also details

the case of a woman, aged 41, on awakening from narcosis, in which a third injection of paraffin had been made into the nasal region, for correcting a "saddle-"nose, could not see out of the previously normal left eye. Examination on the next day revealed amaurosis, no pupillary reaction and the typical picture of embolism of the central artery. Paracentesis of the anterior chamber was of no avail. Nine months later the writer found the direct reaction of the pupil abolished, the consensual, and that on convergence prompt, the disc very pale, glaucomatous excavation and chorio-retinitic changes. He ascribes the affection not to an embolism, which would require that a particle of paraffin pass through the capillaries of the lungs, but to an interruption of the blood supply to the central retinal artery. A review of cases of embolism observed after injections of paraffin, shows that after injections into the nasal region only the eye was damaged and never other organs, especially the lungs, and that, on the other hand, after numerous injections into the urogenital region embolism of the lungs but never embolism of the central retinal artery was discovered. This strongly suggests that between the place of injection at the usual nasal region and the interruption of the blood current in the central retinal artery certain direct relations must exist.

To avoid accidents in this connection Wurdemann suggests that the following precautions be taken: 1. Paraffin which melts at a low degree of 41° or 42° only should be employed. 2. Pressure during the injection is to be avoided. 3. The injection is to be made through a thick canula, so that piercing of a vein should be rendered more difficult. 4. An assistant should exercise strong compression at the angles of both eyes, thus preventing the injection of paraffin into the orbital veins. 5. A very small amount should be injected at one time; only from 1 to 1.5 cc.

Paraffin jelly. See **Cosmoline**, p. 3543, Vol. V of this *Encyclopedia*.

Paraffinum molle. See **Cosmoline.**

Paraform. PARAFORMALDEHYD. TRIFORMOL. This is a white, crystalline substance—a polymere of formaldehyd—used both internally (½ to 1 grm.) and externally as an antiseptic. Lewin and Guillery place this agent in the list of those that cause amblyopia.

Paragraphia. A minor degree of agraphia. See p. 198, Vol. I of this *Encyclopedia*; also **Visual aphasia**; and **Neurology of the eye.**

Paraheliotropism. A form of negative heliotropism.

Paraiodophenol. PHENOL IODIDE. PARAPHENOL IODIDE. Reddish or colorless crystals smelling of iodine and carbolic acid. It may be applied pure or diluted to corneal ulcers, and when so used is a very efficient cauterant.

Paralexia. Inability to read words as they are written. See **Visual aphasia.**

Paralisi progressiva degli alienati. (It.) Progressive paralysis of the insane.

Parallax. 1. Apparent displacement of an object due to change of the observer's position. 2. The apparent shifting of the position of an object when a screen is passed alternately from one eye to the other. It is said to be *homonymous* or *direct* when the object appears to move in the opposite direction to the screen, i. e., moves to the side of the eye which is uncovered; *heteronymous* or *crossed* when the object moves in the same direction as the screen. The former indicates undue convergence, the latter undue divergence, of the usual axes. See **Parallax test.**

Parallax, Binocular. 1. The seeming difference in position of an object as seen separately by one eye and then by the other, the head remaining stationary. 2. The angle of convergence of the visual axes.

Parallax, Entoptic. A term employed by Listing to indicate the movement of the shadows in the entoptic visual field.

Parallax tests. In *glaucoma*, when the indirect method of viewing the fundus is employed, the difference in level between the scleral ring and the papilla proper can be recognized by parallactic movement, the bottom of the excavation seeming to move at a different rate than the surrounding parts.

The application of the parallax to tests for *binocular vision and heterophoria* was first described by Alfred Graefe. It has been modified and popularized in the United States by Alexander Duane under the name of Duane's screen, cover or parallax test. Duane describes it as follows: "If there is any noticeable deflection behind the screen, the *screen-test is applied in a second way* or by *binocular uncovering.* This procedure consists in covering the left eye and then uncovering both eyes and noticing the movements that take place. If, on thus uncovering the left eye, the right eye remains steady and the left moves into position, the patient has binocular fixation, and the deflection was a heterophoria and not a squint. If, however, the right eye should move out of its position and the left eye should move into place, there is a squint and the left is the fixing eye. If neither eye moves, there is a squint and the right is the fixing eye. By repeating this experiment with each eye alternately the examiner can tell whether there is an habitual binocular fixation, an alternating fixation, or a uniocular squint."

Parallax, Vertical. That state of the eyesight in which the thing observed appears to move upward or downward.

Parallel rays of light. Rays that proceed from infinity; a *beam of light.*

Parallelometer. An appliance for determining parallelism.

Paralysis agitans. As stated by Hirsch (*The Eye and Nervous System*, p. 477), and in the experience of the Editor and others, ocular symptoms do not form an essential feature of paralysis agitans. There are a few cases on record in which paralysis agitans was combined with other diseases of the central nervous system, as, for instance, locomotor ataxia. The loss of pupillary reflexes or affections of the optic nerve in cases of this kind would, of course, not form a feature of paralysis agitans, but of the complicating disease. Inasmuch, however, as in paralysis agitans the muscular apparatus of the entire body is apt to be affected in a characteristic manner, it is evident that the muscles of the eye may once in a while show the same morbid condition, although as a rule they escape even this affection. The characteristic condition of the muscles consists of the typical rhythmical tremor, and of a very marked tension, which interferes with normal motion, so that in the later stages the individual may become nearly unable to perform any movements at all, although there is no true paralysis in the ordinary sense. The main difficulty in performing motions adequate to their purpose seems to arise from the inability of the patient to contract a group of muscles suddenly after they are at rest, or to relax them quickly when they are contracted. Both these functions are indispensable to normal motion. This condition would also explain the inability of the patient to arrest the body suddenly when in locomotion, a symptom known by the names of propulsion, retropulsion and lateropulsion. If a person who is walking wants to arrest this locomotion suddenly, he must quickly contract the antagonistic muscles, must throw the trunk in the opposite direction, a function which an individual afflicted with paralysis agitans is unable to perform. If now we apply this condition of the muscular apparatus to the muscles of the eye, we would expect quite a number of interesting phenomena. To the tremor would apparently correspond a *nystagmus*. But this symptom has never been observed in paralysis agitans. This fact furnishes another proof for the assumption that nystagmus is produced by some central lesion and not by a disturbance in the general muscular tonus, because if the latter view were correct we would be bound to observe this symptom at least occasionally in paralysis agitans. The tension and rigidity do occur in the ocular muscles, although far less frequently than one would expect. The sphincter is never affected; the pupils have always been found normal in this disease. Likewise the optic nerve always remains unimpaired. The rigidity is very apt to show itself in the

orbicularis, thus interfering with the mimical motions, the expression of the features, and therefore contributing to the mask-like appearance of the face. The closing and opening of the eye is sometimes very slow and sluggish, and in a few cases there was a partial ptosis. In order to assist in the opening of the eyes, the musculi frontales are contracted, and on account of the difficulty in relaxing the muscles, patients often have marked wrinkles in the forehead. The movements of the eyeballs are sometimes somewhat retarded. A few cases have been observed where there was great difficulty in convergence; also a spasm of accommodation has been described. In one case Graefe's symptom occurred on one side in the hemilateral form of the disease.

In a case reported by Minkowski there was a complete ophthalmoplegia externa. Both eyes were entirely closed and could not be opened by the patient. When one raised the lids with the finger, the eyeballs stood in parallel axis, directed straight forward, without ability on the part of the patient to move them in any direction.

The surgeon is also interested in the difficulties that attend delicate ophthalmic operations on subjects affected by paralysis agitans. C. A. Ringle (*Annals of Ophthalmology*, p. 180, Jan., 1913) has reported the history of a farmer aged fifty-eight, who came on account of bilateral cataract which had reduced vision to light perception, but who at the same time was suffering from paralysis agitans. In spite of the poor vision, the cataracts were immature. The eyes appeared to be otherwise normal, but examination was made extremely difficult by the marked muscular tremor produced on attempting to hold the eyes open. On account of the usual objections to general anesthesia in cataract extraction the first attempt at removal of the lens was made after administration of a quarter of a grain of morphin and a hundredth of hyoscin hypodermically. The muscular tremor and spasm were apparently quieted, and the patient was sound asleep soon after getting on the operating table. But when spoken to he would arouse, and would turn his eyes in any required direction. The eye was cocainized, the speculum inserted without resistance, and iridectomy and capsulotomy performed without incident. But as the spoon and spatula were being taken in hand, there was a sudden gush of fluid vitreous. At the command to keep still and not squeeze the eye, there were repeated spasms of the orbicularis. The speculum was at once removed, and, as the slightest disturbance caused the patient to squeeze the eye shut, a dressing was applied. It was impossible to examine the eye until ten days after operation, when ideal healing was in progress, and the lens was seen to be in position, but its opacity markedly increased. After

six weeks a second attempt was made, a hypodermic injection of morphin and hyoscin being given, and deep anesthesia completed by means of a few drops of chloroform. A perfectly straightforward extraction was done without loss of vitreous. There was no nausea after recovery from the anesthetic, and six weeks after the second operation vision of 20/70 was obtained. See, also, the minor caption *Paralysis agitans* under **Neurology of the eye,** p. 8351, Vol. XI of this *Encyclopedia.*

Paralysis, Abducens. See **Muscles, Ocular** and **Ophthalmoplegia externa.**

Paralysis and paresis of eye muscles. See **Ophthalmoplegia.**

Paralysis, Asthenic, Eye symptoms of. Erb's disease. See p. 4505, Vol. VI, as well as p. 8256 and p. 8348, Vol. XI of this *Encyclopedia.*

Paralysis, Brown-Séquard. The symptoms are paralysis of motion on one side and of sensation on the other. A case reported by Geo. W. Hall (*Annals of Ophthalmology*, p. 575, July, 1913) showed ocular involvement of the sympathetic nerve. The patient gave an indefinite history of specific lesion some years before. His trouble began suddenly on the 10th of August, 1912. While standing, about 4 o'clock in the afternoon, he suddenly became paralyzed on the left side, with complete loss of sensation. A week before he had had slight sensation in the back of the neck, which he thought was due to a cold or draught playing upon the neck. Between times there was no disturbance. For some time he had had a slight pain in the back of the neck, but this soon disappeared. He also had previously suffered from marked ptosis of the right eye with contracted pupil and a slightly sunken eyeball. Lumbar puncture disclosed an increased number of lymphocytes in the spinal fluid, with a slight reaction to the Noguchi test. He was put upon mixed treatment and showed considerable improvement, but still showed practically complete loss of sensation upon the right side of the face, which included the distribution of the sensory portion of the fifth nerve without involvement of the motor portion. There was no evidence of motor disturbance, the masseters contracting equally on both sides. The right sclera showed marked anesthesia. He had complete loss of the Brown-Séquard syndrome on the left side, the loss of temperature and pain sense with the presence of tactile sense.

Paralysis, Bulbar. See **Bulbar and pseudobulbar diseases,** p. 1324, Vol. II of this *Encyclopedia;* also **Neurology of the eye.**

Paralysis, Conjugate. See p. 2997, Vol. IV of this *Encyclopedia.*

Paralysis, Infantile cerebral. See p. 6193, Vol. VIII, as well as p. 8340, Vol. XI of this *Encyclopedia.*

Paralysis, Infantile spinal. ACUTE ANTERIOR POLIOMYELITIS. For the eye signs see **Neurology of the eye,** p. 8354, Vol. XI of this *Encyclopedia.*

Paralysis, Oculomotor. See **Ophthalmoplegia.**

Paralysis of accommodation. See **Ophthalmoplegia interna.**

Paralysis of convergence. See **Ophthalmoplegia.**

Paralysis of divergence. See **Ophthalmoplegia.**

Paralysis of external rectus. See **Ophthalmoplegia.**

Paralysis of the brachial plexus. The ocular symptoms are discussed under an identical sub-head in **Neurology of the eye,** p. 8353, Vol. XI of this *Encyclopedia.*

Paralysis of the fifth nerve. See p. 5194, Vol. VII of this *Encyclopedia.*

Paralysis of the fourth nerve. See **Muscles, Ocular**; also **Ophthalmoplegia,** as well as p. 5279, Vol. VII of this *Encyclopedia.*

Paralysis of the inferior oblique. As is well known, isolated paralysis of an inferior oblique muscle is very rare. It occurs from 1 in 2,000 to 1 in 7,000 cases, according to different authors. Inouye (*Klin. Monatsbl. f. Augenheilk.*, Feb. 1912; *Ophthalmology*, p. 207, Apr., 1915) reports one case.

A woman, 27 years of age, suffered from empyema of the left antrum of Highmore, in the course of which acute articular rheumatism supervened. The operative treatment of the empyema, and subsequent syringing, led to closure of the left eye by swelling of the lids. When this swelling subsided, after a week or two, the patient complained of diplopia. Under the circumstances, it was impossible to ascertain at what date the deviation of the eye occurred.

Diplopia was vertical, the image of the left eye being the lower, and the upper end of the right image being rotated outwards. The vertical displacemnt diminished slightly both in upward and in downward movement of the eyes. When the eyes were turned to the left, the vertical displacement increased, while the obliquity of the right image diminished, the opposite effects occurring with rotation of the eyes to the right. This behavior of the images in lateral rotation of the eyes suggests paralysis of the left inferior rectus, but there was no increase of the vertical deviation on lowering the gaze, and no difference between primary and secondary deviation. Inouye points out that, if we assume that the paralysis had been in existence for several weeks, this would be explained by the tendency which paralytic squints show to assume the characters of the concomitant type. In such typical cases, however, valuable information may be obtained by studying, as Bielschowsky recommends, the effect on the double images of lateral inclinations of the head. The phenomena as described above might

be due to paralysis, either of the left inferior rectus or of the right inferior oblique. The former rolls the left eye outwards, and the latter rolls the right eye outwards. Under normal conditions, when the head is inclined to one side there is produced reflexly a torsion of both eyes in the opposite direction. When the head is inclined to the left, the muscles which produce the necessary torsion of the eyes to the right are the right inferior oblique and inferior rectus, and the left superior oblique and superior rectus. Thus in each eye the muscles act together in their torsional effect, but are antagonists as regards vertical movement. If, now, the right inferior oblique is paralyzed, and the head is inclined to the left, the right inferior rectus acting without its oblique antagonist draws the right eye downwards. This is actually what occurred in Inouye's case, and he concludes that the affected muscle was the right inferior oblique. As regards the connection between this and the affection of the left maxillary antrum, he assumes a nuclear lesion caused by metastasis. Recovery occurred in three months.

Steindorff (*Klin. Monatsbl. f. Augenheilk.*, Oct. 1913) also reports a case and finds thirteen such instances in the literature. He believes it to be due usually to trauma of the inferior orbital region or to operation in the neighborhood of the muscle. Other cases have been attributed to syphilis and rheumatism. The prognosis is uncertain, but is not always unfavorable. Recovery may occur in cases where the nerve has been injured by blood effusion or by some removable cause.

Steindorff's case developed diplopia and limitation of ocular movement shortly after evacuation and scraping of frontal, ethmoid, and sphenoid sinuses. The eyes were in other respects normal, and Wassermann's reaction was negative. Operation, in the form of tenotomy of the opposite rectus superior, followed by advancement of the opposite inferior rectus, was ineffectual.

Paralysis of the inferior rectus. See **Muscles, Ocular,** and **Ophthalmoplegia.**

Paralysis of the insane. See **Paresis, General,** also p. 8352, Vol. XI and p. 6370, Vol. VIII of this *Encyclopedia.*

Paralysis of the internal rectus. See **Ophthalmoplegia externa.**

Paralysis of the levator palpebræ superioris. See **Ptosis,** as well as **Ophthalmoplegia externa.**

Paralysis of the ocular muscles. See **Ophthalmoplegia**; as well as **Ocular muscles** and separate captions of **Muscles.**

Paralysis of the orbicularis palpebrarum. See p. 5136, Vol. VII of this *Encyclopedia.*

Paralysis of the seventh nerve. See p. 5136, Vol. VII of this *Encyclopedia.*

Paralysis of the sixth nerve. See p. 8142, Vol. XI of this *Encyclopedia.*

In addition to what is there found it may here be said that two hundred and fifty cases of paralysis of the 6th nerve, with brief clinical histories, are reported by Koellner (*Deutsche med. Woch.*, 1908, p. 112). Among the causes given are intoxications, alcohol, lead, drugs (anthelmintics, but it could not be ascertained which), stovain, tropacocain, novocain in lumbar anesthesia; infections, malaria, influenza, erysipelas of the face; diseases of the kidneys, albuminuria, diabetes; disturbances of circulation, as arteriosclerosis leading to hemorrhages, miliary aneurisms and foci of softening in the nucleus, sclerotic changes of the internal carotid, which crosses the abducens twice; diseases of the central nervous system; lues of the brain, tabes, multiple sclerosis, polioencephalitis, chronic progressive ophthalmoplegia, cerebral tumors, myasthenia gravis pseudoparalytica, hysteria, hemicrania; vasomotor disturbances; traumatic, octogenous (the exact cause in the 4 cases reported could not be ascertained), congenital palsies, and paralysis without ascertainable cause.

The isolated paralysis of the abducens was most frequently observed if toxic substances invaded the organism, either chemicals or from infectious diseases, or in disturbances of circulation. Both led to changes of the vascular walls, with subsequent motor derangements of the ocular muscles, chiefly the abducens, owing to its long course through the cavernous sinus. The isolated palsy is either nuclear or basal, especially in injuries of the apex of the pyramid of the petrous bone. It must also be remembered that the 6th nerve crosses the posterior inferior cerebellar, the auditive, and internal carotid arteries. If damaged at its exit from the brain, it generally is associated with focal symptoms of other nerves. Each isolated palsy of the abducens calls for repeated careful examinations of the whole nervous system. Although the prognosis of infectious and toxic palsies is on the whole favorable, it may be the precursor of a commencing nervous trouble, e. g., in tabes paralysis of the abducens with and without iridoplegia may be the only affection of a cranial nerve. Koellner's cases show that in a great number of isolated palsies of the abducens other, even slight, disturbances of the remaining nerves may be of diagnostic value with regard to etiology. The frequency of the various etiological factors is illustrated by the following table:

	Isolated paralysis of the abducens.	Isolated paralysis of the abducens with simultaneous affections of the choroid and retina.	Paralysis of the abducens combined with other ocular palsies.
Chronic alcoholism	3	..	3
Intoxication by lead	2	..	..
Intoxication by other drugs	1	..	..
Malaria	1	..	..
Influenza (acute neuritis)	4	..	..
Erysipelas	1	..	..
Nephritis	5	1	4
Diabetes	1	..	..
Diseases of the circulatory system	4	..	1
Chronic meningitis	2	..	6
Acquired lues	14	1	25
Hereditary lues	..	2	..
Tabes	11	..	59
Paralytic dementia	..	..	1
Multiple sclerosis	2	..	5
Polioencephalitis	..	..	2
Chronic progressive ophthalmoplegia	..	..	1
Myasthenia gravis	..	..	6
Hysteria	3	..	..
Hemicrania	4	..	..
Vasomotor disturbances	4	..	..
Traumatism	6	..	7
Lumbar anesthesia	1	..	2
Diseases of the ear	2	..	13
Tumors of the brain	..	..	..
Without definite diagnosis	32	..	8
	103	4	143

Paralysis of the sphincter pupillæ. See **Cycloplegia,** p. 3641, Vol. V of this *Encyclopedia.*

Paralysis of the superior oblique. See p. 5279, Vol. VII and p. 8142, Vol. XI of this *Encyclopedia.*

Paralysis of the superior rectus. See **Ophthalmoplegia externa,** as well as p. 8142, Vol. XI of this *Encyclopedia.*

Paralysis of the third nerve. See **Ophthalmoplegia externa**; also p. 8142, Vol. XI of this *Encyclopedia.*

Paralysis, Progressive general. See **Paresis, General.**

Paralysis, Pseudobulbar. See p. 1324, Vol. II and p. 8355, Vol XI, of this *Encyclopedia.*

Paralysis, Trochlear. See **Paralysis of the superior oblique.**

Paralyzing vertigo. GERLIER'S DISEASE. See p. 5369, Vol. VII of this *Encyclopedia.*

Paramacular. About or encircling the macular region; for example, a paramacular *scotoma.*

Paramonochlorophenol. See **Monochlorophenol,** p. 7855, Vol. X of this *Encyclopedia.*

Paranephrin. The trade name (Merck) of a substance obtained from the suprarenal glands without the aid of acids or alkalies. It is marketed in 1:1000 sterile solution with 0.60 per cent. of sodium chloride. The bottles contain 10 cc. (150 minims) of the solution.

It is one of the most reliable of the adrenal preparations and, like adrenaline and other agents of the kind, is used alone or in conjunction with local anesthetics in ophthalmic practice.

Paranoia. See under **Neurology of the eye.**

Paranthelion. A white diffuse image of the sun, formed at the same altitude with it, but at an angular distance of from 90° to 140°.

Paraphenol iodide. See **Paraiodophenol.**

Paraselene. A bright spot on a lunar halo; a mock moon.

Parasites, Ocular. A consideration of animal parasites which attack or affect the eye may be conveniently undertaken by grouping the material of significance under four headings corresponding to natural phases of the general problem.

First: Those animal organisms which in some instances have been present in fact and have made a direct attack upon some structure contained in the optic cavity or lining its external opening.

Second: Those animal parasites which exert indirect influences upon the optic organ or its adnexa since by their attack on some other and distant organ of the body they in one way or another affect the eye, it may be in its structure or only in a purely functional manner.

Third: Those parasites which in other hosts than man attack the optic organ and which being adapted to conditions of existence as ocular parasites may under circumstances be brought into relation to the human eye and become parasitic in it.

Fourth: Those objects which have been detected in the human eye and have been described and classified as parasites but which are not such; these are commonly designated as pseudo-parasites.

The class of objects included under the last heading may conveniently be considered first of all in order to remove from the field of inquiry the confusion and error which such have brought into the study of animal parasites in every field and which in special ways have entered into the study of ocular parasites.

As pseudo-parasites should be classed all objects in and about the optic organ which under general or special conditions assume such a character as to lead to their classification as animal parasites invading the eye. In dealing with other organs the group of pseudo-parasites furnishes to the diagnostician problems of great importance. The number of structures which have been interpreted as parasites and yet are not truly such is large but most of them are related to the alimentary system or some part of it and but a few of them are of any special significance in the study of the eye. Attention will be given here only to this latter class.

It is wise to call attention at the outset to certain real difficulties which are sometimes overlooked in making a definition of this group. the class of pseudo-parasites should be limited to two types: (1) to such structures as are not organisms at all; and (2) to those organisms which though caught in the parasitic relation apparently are really free-living animals incapable of assuming a parasitic rôle. The term does not naturally or correctly include those organisms which are parasitic but commonly infest some other host than the human species, and in the cases under consideration are found by chance in the parasitic relation to the human species. Such parasites are those which circumstances have caused to wander from their proper location and be carried into the human optic organ under relations sufficiently favorable to enable them to establish a place there temporarily.

A splendid example of this latter condition is furnished by the fish-lice. These are somewhat aberrant crustacea that normally exist as external parasites on the outer surface of the body of marine vertebrates, especially fish. They are not lacking in power to move and even to carry on an independent existence for a brief period so that at times when separated from the host they do live, swimming about through the water and searching meanwhile for a resting place on a new host. If a fisherman plying his trade scrapes off from the surface of a fish he is handling large numbers of these organisms, as in fact happens many times in the course of natural events, it is not strange that sometimes a fish-louse adheres firmly to the finger by which it was carried away from its normal location. So long as the finger is moistened by salt water the fish-louse finds it a possible abiding place, but under usual conditions the parasite is wiped off or dried out and falls off within a short time. If, on the other hand, the fisherman pauses a moment in his occupation to brush a dash of salt water off his face, or to rub his eye, then it is not strange if such a parasite is transferred mechanically and without any special notice of its presence to the surface of the conjunctiva. Here it finds a

temporary but satisfactory home on the moist and delicate membrane bathed continually by the flow of fresh fluid, and affording in the corners underneath the lids a splendid hiding place for any such minute organism. The organism in question is by no means a pseudo-parasite for it is normally adapted to the carrying on of the parasitic existence and if not mechanically interfered with would continue under the original circumstances indefinitely. It may be reasonably recorded as an erratic parasite of the human species.

In this connection it is appropriate to note that a very considerable number of parasites which have been recorded from the human eye are not normal parasites to the human species or commonly to be found in any relation to that host. They are organisms, to be sure, which visit the human host occasionally, or such as usually infest some other region of that host, and in the special case have come into particular relations with the optic organ. They are human parasites in a fuller sense than are the fish-lice but they are not true or typical ocular parasites, but may be termed occasional parasites of the eye. Further data concerning such organisms will be brought out in the special discussions of individual species later on in this article.

It also happens that animals which are normally free-living are brought into such relations to some part of the living organism that they adopt temporarily or in transient fashion parasitic relation to that organism. Thus, for example, larvæ of aquatic insects depend upon fresh water conditions of some sort or other for development. It may happen, however, that chance brings some such larva into the eye and that in the conjunctival sac it finds a moist environment such that further development is possible. Being small and inactive and not sufficiently irritating to provoke a strong reaction it remains in this location for a period. Superficially at least, it has assumed to a degree a parasitic habit. It is, however, in the accepted use of terms, neither a parasite nor a pseudo-parasite. It is a free-living organism which has accidentally assumed a parasitic habit and should be classed accordingly as an accidental parasite.

As pseudo-parasites proper are classified those objects which do not adapt themselves to the parasitic habit, so far as the eye is concerned they are few in number. They fall into two classes, (1) living organisms and (2) fragments of one sort or another. As pseudo-parasites of the first type would be recognized in the case of the alimentary canal those living organisms which had passed through the tube and had been recovered from fecal material but never had really assumed even temporarily the rôle of parasites. Naturally this type does not come under the consideration of the ophthalmologist.

As the second group of pseudo-parasites, one may classify those parts of the host organism which under unusual conditions assume some aberrant form that is sufficiently suggestive in a superficial way of an invading organism to be diagnosed as such. Thus in examinations with the ophthalmoscope there have been detected in the human eye in various instances structures of an unusual type, which were labelled parasites by the discoverer. Undoubtedly the most familiar of these in connection with the human eye is the remnant of a persistent hyaloid artery. In form, size, and color it resembles a nematode worm and under the influence of eye movements or modification in tension either in the vessels of the eye or in the eyeball itself such a structure moves, in a fashion, to simulate a living organism. The positive demonstration of error in some instances has led parasitologists to reject all cases in which a filaria in the eye has been demonstrated exclusively by the ophthalmoscope. Most of these cases are old; they include such reports as that of Quadri (*Compt. rend. congrès d'opthal.*, Bruxelles, session de 1857) which though apparently confirmed by della Chiaje is pronounced by later observers to be nothing more than a persistent hyaloid artery. Fano also (*Union méd.*, Paris, 5, p. 389, 1868) observed a "living filaria in the vitreous body" in a child of 12 years which he re-examined after 8 years and found but little changed. Despite this he reasserted his original diagnosis, but others have been unwilling to accept it. Schöler (*Berl. klin. Woch.*, 12, p. 682, 1875) showed before the Berlin Medical Society a woman with a living nematode 12 to 15 mm. long which was rolled in a spiral and actively moving in the lens. Virchow is reported to have examined the specimen carefully. The diagnosis of the demonstrator has not been accepted. Eversbusch (*Münch., med. Woch.*, 38 p. 532, 1891) made a preliminary report on a presumed living worm in the vitreous; the promised, more extended, description has never been published. To judge from the data given, the object was probably also a persistent hyaloid artery.

These, and other cases not cited, illustrate clearly the ease with which even an observer of experience can be deceived by appearances in some cases and demonstrate the justification for rejecting all such records unless confirmed by the extraction of the worm.

Another chance for confusion in records concerning supposed ocular parasites is presented in cases of a cysticercus or bladder-worm. It has been suggested by various persons that errors in interpretation are possible if observations are not most critically made and full data secured. Evidently pathologic growths of a certain form and location would be easily confused with a cysticercus. While such inferences

have been drawn by reviewers the proof of such misinterpretation has not been furnished in any case that I have found on record.

TRUE OCULAR PARASITES

In considering the animal parasites of the first group, viz., those that attack the eye directly, one may group them most conveniently according to the zoological scheme of classification, bringing together those forms which are structurally related and discussing them under headings corresponding to the group to which they belong. Of the various groups in which animals are classified only a few furnish parasites; these are, among the Protozoa or unicellular animals, the Flagellata and the Sporozoa; among the Plathelminthes, or flatworms, the Trematoda, or flukes, and the Cestoda or tapeworms; among the Nemathelminthes, or roundworms the Nematoda; among the Cœlhelminthes, or cœlomic worms, the Hirudinea or leeches, and among the Arthropoda, the Crustacea and Insecta. These groups will be taken up seriatim and those forms discussed which are significant as ocular parasites.

PROTOZOA

Investigations of the more recent years have disclosed the previously unsuspected but very important rôle played by Protozoa as human parasites. A multitude of new forms have been discovered and most serious consequences ascertained in their general relations to the human organism. Few of these parasites have been investigated in regard to possible relations to the eye such as are known and are to be discussed between the multicellular parasites of man and the eye. How little this field has been worked will be apparent on examination of the literature bearing on the eye. The following summary, though brief, will give a survey of the various aspects of what is known on the relations of unicellular parasites to the optic organ and its adnexa.

In sleeping-sickness or trypanosomiasis, a disease of the African continent caused by one of the flagellate protozoa, *Trypanosoma gambiense*, in the circulating blood and later in the cerebro-spinal fluid, some eye symptoms and changes are reported. Externally conspicuous are loss of light reflex, engorgement of the iris and wide dilation of the pupil. More profound are iritis, cyclitis, choroiditis, and even optic neuritis of a transient character, in the retina by this parasite. One can hardly doubt that profound changes are evoked.

The relapsing fevers in which the organism is a spirochæte are frequently complicated by iritis or iridocyclitis; this condition is protracted though it ultimately terminates favorably.

Another form of flagellate protozoan parasite in man is Leishmania, found as an intracellular parasite; it is oval in form with nucleus and blepharoplast but no flagellum in the resting stage from human tissue. There are three species, viz.: *Leishmania donovani,* the cause of kala-azar in India, a general systemic disease; *L. infantum,* the cause of infantile kala-azar in circum-mediterranean countries, perhaps only a variety of the first-named species; and *L. tropica* the parasite of Delhi boil or oriental sore. This is a localized skin disease and as such may easily attack the eyelids. Such diseases as are caused by these parasites are designated Leishmaniases; the parasites themselves are apparently alike in structure. They consist in the human stage of oval bodies containing two chromatin masses. Multiplication is by fission either binary or multiple. When cultivated in artificial media, the organism becomes a herpetomonad with one flagellum. The culture method is useful in diagnosing these parasites.

Some observations have been made by Trantas (*Arch. de méd.*, 10, p. 276, 1915) on ophthalmoscopic changes in generalized leishmaniasis or systemic kala-azar due to *Leishmania donovani.* The first case, a man of 26 years, had suffered from kala-azar for six months, and had been treated in a hospital with benefit. In the right eye was seen a hemorrhage in the lower half of the retina, 6-7 mm. in diameter, round and with irregular borders. The optic papilla was dark and much altered in appearance; its edge was only discernible on the temporal side, possibly from staining with effused blood. The arteries and veins were moderately dilated. Slight loss of pigmentation could be noted in the choroid towards the periphery. In the left eye was seen a slightly less discoloration of the optic papilla. At the edge of the disc was a red spot looking like a hemorrhage, but disappearing when the eyeball was pressed with the finger during the ophthalmoscopic examination; therefore, probably only a dilated vessel. Towards the periphery of the field one saw loss of choroidal pigment, so as to produce white patches. Vision was normal.

In the second case, a boy, aged 11 years, no hemorrhages were seen in either eye, or alteration of the papilla, but much pachy pigmentation of the retina, with, in parts, choroidal atrophy. In both cases the parasite of kala-azar had been duly found, so that the diagnosis was positive.

Leishmania tropica occurs on the eyelids in the form of a sore or boil. The incubation period is long and one attack confers immunity. The mode of transfer is unknown though Wenyon has developed the flagellate stage in the intestine of *Stegomyia calopus* in

Bagdad, and Patton has also done the same in the bedbug. Various other blood-sucking insects have been suspected in other regions.

Cases in which this parasite occurs on the eyelids have been successfully handled by treatment with carbon dioxide snow.

Malaria is produced by a blood-inhabiting protozoon belonging to the class Sporozoa and the genus Plasmodium.

There are three well-marked forms of the disease and a definite type of malarial organism for each; these are *Plasmodium vivax* Grassi e Feletti 1890, which is the casual agent in simple or benign tertian fever; *Plasmodium malaria* Laveran 1883, which is the parasite in quartan malaria; *Plasmodium falciparum* Welch 1897 by which malignant tertian malaria is produced. The literature on malaria is enormous; until very recently it has been custom to designate all tropical fevers as malaria so that much of a different character is listed under the name. In consequence some eye symptoms and changes may be entered erroneously. Thus by reason of errors in determining the cause in cases reported (Castellani and Chalmers) there is question of the existence of malarial conjunctivitis which has been reported variously in connection with cases of supposed malaria.

Keratitis dendritica first described by Kipp in America is attributed by that author to malaria in 9 out of 10 cases. This is one form of serpiginous corneal ulcer. Keratitis profunda is said by Arlt to be produced by chronic malarial cachexia, among other causes.

Malarial amaurosis may arise during an attack of pernicious fever, or after it. The patient suddenly complains of inability to see. Sight usually returns when the case is treated with quinine; however, thrombosis in retinal vessels, retinal hemorrhages and optic neuritis may result in blindness. A single eye may be attacked. In malarial amaurosis the pupils react to light and generally vision is not totally lost; in quinine amaurosis one notes extreme dilation of the pupils and lack of pupillary reaction; at the same time deafness and roaring in the ears are indicative of cinchonism.

The engorgement of vessels in the choroid and retina with corpuscles loaded with malarial parasites bring about an inflammation found in both acute and chronic malaria. The retina is pale, the papilla obscure, and retinal hemorrhages are frequent. The amblyopia may be temporary or permanent. Atrophy of the capillaries in the choroid exists in the chronic condition, with changes in the retina.

Attention should be called to the possibility that the effects on the eye produced by some parasitic Protozoa may be of double character. Those parasites which like the *Plasmodium malaria* are present in large numbers in the circulating blood and thus reach the various optic

vessels, are there brought into direct contact with the tissues of the optic organ and affect them directly. At the same time it is known in this instance definitely that the parasites discharge into the blood stream large quantities of toxic substances, the end products of metabolism, which exert upon the system generally, and of course therewith upon the eye, effects that are similar to those exerted by parasites which live only in distant parts of the body and do not come in contact with the eye. Such effects are ordinarily classed as indirect or general rather than as immediate or specific; they are discussed for metazoan parasites in a special section, and are to be regarded as manifestations of a general toxemia. Very likely other parasitic Protozoa than those discussed here exert such influences on the optic organ of the host. Our knowledge of parasitic Protozoa is of such recent date that special features in the effects produced have not as yet received consideration at the hands of investigators in special fields.

For want of a better place to treat the topic one may include here references to some peculiar but important cases which might be classed as accidental parasitism and which concern the eye as an entrance gate for parasitic invasion of the human host. Ordinarily the ectodermal tissues present a barrier to the entrance of parasites that is wanting on the surface of the optic organ where the character of the outer layer is greatly modified.

That the delicate mucous membrane of the eye can furnish access to deeper tissue for parasites has been assumed generally. In at least one instance it has been demonstrated experimentally though unintentionally on the human host. Sergent (*Compt. rend. soc. biol.*, 75, p. 185, 1913) relates that while a group of three investigators were injecting blood loaded with spirochætes into a monkey, the syringe slipped with the result that the infected blood was spattered over the forehead and eyes of all three persons at work. One of the three wore glasses which prevented the blood from reaching the conjunctiva and he experienced no effects from the accident. The other two received some blood in the eye and eight days later both came down with a typical attack of relapsing fever which was successfully treated with salvarsan. It seems to be clear that the inoculation in these two cases was achieved through the conjunctiva especially as the man whose eyes were protected by his spectacles escaped being infected.

The same power of such organisms to penetrate the sound conjunctiva had been demonstrated somewhat earlier by Brumpt (*Bull. soc. path. exot.*, Paris, 5, p. 723, 1913) in experiments with a monkey (*Cercopithecus ruber*). He was working with dejections of Conorhinus

and Cimex infected with *Schizotrypanum cruzi* and found the material very virulent since it contained active trypanosomes. Such dejections brought onto the skin of the monkey or rat were not infective as they dried up very rapidly and the flagellates died. But on the other hand when such dejections were deposited on the bulbus oculi of an adult vigorous *Cercopithecus ruber* they infected the animal and death followed in a month, as soon as if it had been inoculated on the peritoneum.

Chlamydozoa. It would be unwise to pass without mention this subject which is still in the controversial stage and concerning which the views of different observers are widely at variance. It must be confessed that the demonstration is by no means complete and that many and serious criticisms can be offered against the views of those who regard the structures to be described as independent organisms of parasitic habit. Nevertheless, that this survey of the field may be reasonably complete it is proposed to present here in brief form the views of various investigators as to the structure and nature of these bodies. This is all the more necessary because whatever be the character of such bodies they hold a position of prime importance in the pathology of the optic organ. And a considerable number of the most expert parasitologists are strong supporters of the view that the bodies represent minute animal parasites of a type not heretofore known but of marked significance among the causes of disease.

The name Chlamydozoa was proposed by Prowazek in 1907 and has come into fairly general usage. For the same groups Lipschütz proposes the name *Strongyloplasmata.* The group includes a considerable number of minute problematic organisms which have been asserted to be the casual agents in various diseases such as vaccinia, variola, molluscum contagiosum, trachoma, hydrophobia, measles, scarlet fever, etc. In each of these diseases the viruses pass through bacterial filters but not through the ultra-filter, i. e., one coated with agar. The filtrate obtained from a Berkfeld filter is virulent and in many cases produces definite and characteristic effects when administered properly to susceptible organisms. As these problematic bodies have been variously interpreted at different times it may be useful to recount the various steps in the progress of our knowledge concerning them.

In certain diseases characteristic inclusions were discovered in cells of specific sorts and these bodies were usually named after the discoverer. Thus in trachoma, Prowazek's bodies were recorded.

As the study of the diseases progressed these structures were considered to be actual parasitic organisms and to be responsible for the

production of the diseased condition. As definite organisms they received zoological names and investigators endeavored to group the various phases under which they appeared into series which were taken to represent the life cycles or developmental cycles.

The evident defects in these arguments lent strength to the opposite view and the bodies came to be interpreted merely as reaction products or the results of the influence of some virus on the protoplasm of the host cells. Many investigators still hold to the view that the structures in question are such degeneration products either of the nucleus or the protoplasm.

The most recent investigations have added strength to the view that they are living organisms of a parasitic character bearing a direct etiologic relation to the diseased condition with which they are found.

These supposed parasites occur in ectodermal tissues, as the cells of the epiderm, including the conjunctiva, and of various nerve centers.

As characteristics of the Chlamydozoa Fantham lists first their extremely minute size. They measure often only 0.1 to 0.2μ being smaller than any bacteria and passing readily through the filters which serve to retain the bacterial organisms. In the second place, he records the presence in the cytoplasm or even in the nucleus of the infected cell various intracellular stages through which they pass and during which are produced those things interpreted as reaction products or cell inclusions which are recognized as sufficiently characteristic to be diagnostic of the disease in question. Finally, he believes that they pass through definite cycles of development which consist essentially of growth and multiple division into minute granules.

Prowazek outlines the life history of the Chlamydozoa such as that of trachoma bodies (Fig. 1) as follows:

1. Elementary bodies which are minute granules of chromatin apparently without cytoplasm and small enough, as already indicated, to pass through the pores of a Berkfeld filter, and are found in a free condition outside the cells of any organism. Brought into proper environment such granules can penetrate a host cell and growing in size within it become initial bodies (Fig. 1, a).

(2) The host cell reacts visibly to the attack as material perhaps of a nuclear character (plastin) is excluded from the nucleus and envelops the initial body producing thus a mantle from which is derived the name Chlamydozoa. This stage of the body represents the characteristic cell inclusions described and recognized in various diseases (Fig. 1, b).

(3) This body thereupon breaks up into a considerable number of

minuter structures known as initial corpuscles which in their turn by simple division give rise to numerous elementary bodies with which the life history began. How these bodies become free, how they are transferred, when and how long they live, are questions to which as yet no answer can be given.

The method of division described here consists in the elongation of the minute granule, the constriction of the mass to produce a dumb-bell-shaped structure and the separation of the ends of the dumb-bell until the connecting bar is drawn out so fine that it breaks.

The trachoma bodies belong to a subdivision in this group in which one finds proliferation of the host cell produced by the parasite. Del Monte (*Arch. di ottal.*, 21, p. 83, 1913) concludes as a result of his studies that it is not possible to determine the nature of the parasite

Fig. 1. Trachoma. Prowazek bodies in infected epithelial cells of the conjunctiva; *a*, initial bodies above, and cluster of elementary bodies touching the nucleus which is in the center; *b*, cluster of granules surrounded by mantles. × 1800 approx. After Fantham.

except that its characters point to a relationship with the simple animals (Protozoa) rather than with the plants. Prowazek, taking into account the results from experimental treatment with various reagents, is inclined to regard them as closely related to the Protozoa.

Experiments have been made to cultivate many of these bodies in various culture media. Noguchi and Cohen (*Jour. Exp. Med.*, 18, p. 572, 1913) have successfully cultivated on special media used for spirochætes, structures which resemble the trachoma bodies and which they believe to be identical with them. They were unsuccessful, however, in their efforts to infect monkeys with material taken from these cultures. See, also **Chlamydozoa**, p. 2060, Vol. III, in this *Encyclopedia*.

TREMATODA

The class called flukes are flattened unsegmented worms belonging to the phylum of Plathelminthes, or flatworms. They are all parasites,

though some occur as ectoparasitic species on water-living vertebrates and others are endoparasitic in all classes of vertebrates. Not many flukes are found in the rôle of human parasites and of only three or four is it recorded that they ever attack the human eye. Two of these are objects of the oldest record of such forms and have been much discussed in ophthalmological as well as in helminthological literature, yet even now their character is uncertain. They are chiefly of historic interest.

Monostomulum lentis Geschiedt 1833. Syn.: *Monostoma lentis.* This case was reported by von Nordmann (*Mikr. Beiträge*, 1, p. 9, 1832) who says that from the lens of an aged woman which had been extirpated for cataract eight specimens of a monostome were removed.

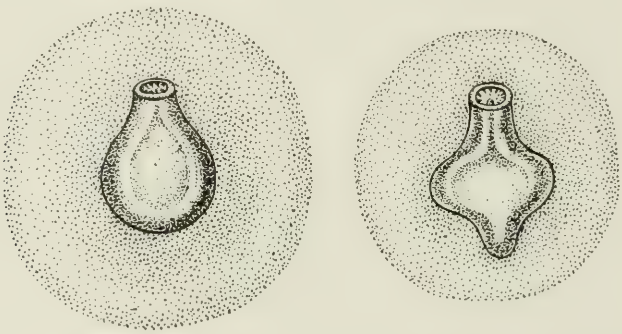


Fig. 2. *Monostomulum lentis.* After von Ammon whose description reads "Figures of *Distoma oculi humani* from the lens capsule of a congenital cataract (Compare Geschiedt, Die Entozoen des Auges. *Zeitschrift für Ophthalmologie*, v. 3 (4)."

They lay in the upper layers of the lens substance and were one-tenth of a line long. When examined in water they moved slowly. It is impossible to say what these really were as the account given is so brief. The figure given by von Ammon and ascribed indirectly to this case is reproduced here (Fig. 2). The original description of this figure is quoted here in translation; it only adds to the confusion as it refers in name to the case represented by the following species and in structure apparently to this to which he also refers by adding the author's name. Since only one sucker is represented the specimen must belong to the monostomes and not to the distomes as the author labels it. Geschiedt says specifically that his specimens were monostomes and we can not reasonably doubt his diagnosis on this point as he was familiar with parasitic worms and a careful observer.

Agamodistomum ophthalmobium (Diesing 1850) was originally described by von Ammon (*Zeitschr. f. Ophthal.*, Dresden, 3, p. 70, 1883)

who obtained the material from a congenital cataract in the eye of a child 5 months old. Four distomes were found in the lens substance by Geschiedt who examined the material microscopically. He later described these as occurring between the capsule and lens. They were one-fourth to one-half line long, one-sixth line broad, with circular terminal mouth, and acetabulum one-third larger than the oral sucker. Some years later von Ammon gave the illustration reproduced here (Fig. 3) with his explanation in translation.

It is clear that the parasite represents a larval distome. Further one cannot go except by uncertain inference. On account of the abundance of certain trematodes in the region where this case was found, authors have inclined to regard the species as a young form of *Fasciola hepatica* the large sheep-liver fluke, or of *Dicrocœlium lanceatum*,

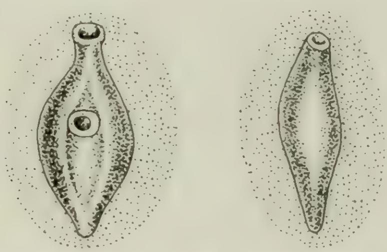


Fig. 3. *Agamodistomum ophthalmobium*. After von Ammon, whose description reads "Figure of a *Distoma oculi humani*, anterior view, and in figure 25 a posterior view."

the smaller or lanceolate sheep-liver fluke, or finally of *Opisthorchis felineus*, a cat-liver fluke. No clear evidence can be adduced in support of any one of these views. The species must remain indeterminate. It is also hard to see how infection can have taken place in so young a child. Leuckart suggested that it wandered in from the mother before the child was born; others have considered it more probable that infection took place through the use of drinking-water in which were by chance free cercariæ, the free infecting stage of a distome.

A much more recent record is that of Greeff (*Klin. Monatsbl. f. Augenheilk.*, 43, 2, p. 171, 1905), who demonstrated two dead shrunken trematode larvæ in a unilateral cataract from the eye of a fisherman. He regarded these as unquestionably the cause of the trouble and thought that they probably had reached the body with the water used in drinking or washing and that they had been conveyed to the eye by the circulation. In justification for their selection or attainment of that special organ he called attention to the fact that in certain regions trematodes are abundant in the eyes of fishes where they cause

cataract in such abundance as to produce veritable epidemics in certain fish ponds. The life history which is reasonably well known in this case gives an explanation of conditions. The adult trematode is parasitic in the alimentary canal of gulls or terns; and the eggs reach the pond water with droppings of the birds; the early stages are passed within a snail and young ciliated larvæ of a second generation swimming about in the water are swallowed by fish and reach the eye where they develop further and disturb the organ so as to produce the pathological conditions already noted. In this case Greeff does not reach even a preliminary determination of the kind of trematode present in the eye of the fisherman. The case contains no data supporting or controverting his hypothesis save its isolated character. No similar case is on record although the fish parasite is common and at certain times its ciliated free swimming infecting stage must be abundant in given water areas. Chance should frequently bring such larvæ into the human system and if they could exist in the human host as in the cold-blooded fish which is the normal host, then one ought to find other cases. It is easier to explain the case as due to erratic individuals of a species normally parasitic in man and usually confined to visceral organs. Circumstances might readily carry a few of such larvæ into the eye in some instances where they became involved in blood currents leading there.

These cases are extremely rare, in fact the only ones of such character on record. In consequence, one may state very positively that no trematodes normally attack the bulbus oculi and that the circumstances which bring about such an infection are so unusual as to recur only at long intervals. There is further no evidence at all that these cases are due to the same species of parasite. It is certain that other cases of similar character will be found from time to time in this country where none have yet been reported. When they are met it will be important for the observer to secure all data possible and to record the same with the maximum accuracy that some definite conclusions may be drawn, first as to the exact kind of parasite present, and second as to the means by which it has reached this unusual location. The second conclusion will probably not be reached until all data have been scrutinized with great care and will depend on the precise recording of every detail as well as upon an intensive study of the material. To make this possible the records of the case should be made at once and in extenso, and the material should be well preserved and kept for future study and comparison with material of known origin.

Man serves as host for a dozen or more trematodes which are con-

fined almost wholly to visceral organs. One of these has been reported in a number of instances as encysted in the eyelid and constitutes thus a normal, if infrequent, ocular parasite; a brief description of this species follows.

Paragonimus ringeri (Cobbold 1880) Syn.: *Distoma ringeri* Cobbold 1880; *D. pulmonis* K., S., and Y., 1881; *D. pulmonale* Baelz 1883; *D. westermani* in part, various authors.

This is the so-called Japanese lung-fluke, common in Japan, Korea, Formosa and some other parts of the East. While the adult usually occurs in cysts along the dorsal border of the lungs, erratic individuals are not infrequently found encysted in other organs. Thus they occur frequently in the eyelids, and also, though less often, in orbital tissue where they may interfere with the movements of the eyes as well as obstruct the vision. Their removal by operative measures is not more difficult than in case of tumors of other origin, nor in any way different from that procedure. The eggs have also been reported as encysted in various organs. This rests in part at least on confusion with the ova of the Japanese blood-fluke, *Schistosoma japonicum,* and further investigation is demanded before one can accept as belonging to this species any such records now available.

The work of various Japanese investigators has now established beyond question the fact that the ova of the blood-fluke which ordinarily accumulate in large numbers in the smaller vessels of the rectum and adjacent structures may be carried to more distant regions and, blocking the vessels, produce emboli which are of the most serious import in the brain. There is every reason to believe that similar stoppages of choroid or retinal vessels may occur. The results on the organ and its functioning would evidently be serious. Thus far I have not found specific reference to the fact of such occurrences. The matter should receive attention in regions where the parasite is found and may be of significance on this continent because of the number of imported cases of the fluke. Many such are found in American literature. There are also many cases of the Japanese lung-fluke here and we are further aware of the presence of a closely related species of lung-fluke, *Paragonimus kellicotti,* found in the lung of the hog, dog, and cat in various parts of the eastern, central, and southern United States.

Three species of blood-fluke are known, viz., the Egyptian species, *Schistosoma haematobium,* the Japanese, *S. japonicum* already mentioned, and a third recently discovered in Panama and the West Indies, *S. mansoni.* All of these are reported in individual cases at least on the American continent and in any case the eggs may be found exceptionally in other parts of the body than those normally and usually

affected. Their presence then in the vessels of the optic organ, though exceptional and not recorded as yet, may nevertheless be looked for as among the rarities of medical experience.

CESTODA

The tape-worms belong to the branch or phylum Plathelminthes commonly designated the flat-worms under which are also included the flukes previously considered. Tape-worms are characterized by a flattened, elongated body usually divided into a series of joints or segments. They are in all cases readily distinguished from the flukes, which they greatly resemble in structure, by the total absence in all stages of development of an alimentary canal or any rudiments thereof. The class Cestoda includes a large number of forms varying considerably in structure despite the general similarity in external appearance. In all species parasitic in the human host the body manifests evident external jointing. The anterior end has a slight enlargement termed the head, or scolex, which is supplied with suckers and sometimes also with hooks.

Like the flukes the tape-worms go through a complicated life history which usually involves a change of hosts. The adult tape-worm lives in the alimentary canal, and fertilized eggs are distributed with the fecal material of the host. They depend upon chance for their introduction into a new host where in the stomach the egg hatches and a minute embryo begins migration through the intestinal wall and into the tissues of this secondary host. Having arrived at the proper place the embryo develops into an oval or spherical bladder-worm designated the Cysticercus in case it is simple. One type of complex multiple larva is called the Echinococcus. The development of the adult from the larval stage is dependent upon the consumption of the flesh containing the living larva by a suitable primary host. In the intestine of this host the bladder-worm becomes the tape-worm by the processes of growth and differentiation.

Adult tape-worms affect the optic organ indirectly only. A discussion of such influences is taken up in another place (see infra). Bladder-worms are larval stages of the tape-worm and are to be met with in almost every organ of the body, even the eye is not immune to their attacks. At least three different species of tape-worm larvæ are known to occur in the eye or its adnexa.

Cysticercus cellulosæ. This bladder-worm is the larval stage of *Tænia solium*, the pork tape-worm of man. It is a more or less spherical or oval bladder which develops rather slowly. At the end of three weeks the diameter of 0.8 mm. is reached, and it is the second month

before one finds the formation in reverse of the scolex with the suckers and hooks of the adult form. It is subject to various malformations which have led to the interpretation of individual cases as belonging to other species. Thus in some instances the hooks are absent so that the observer is inclined to identify it as the larva of the unarmed tape-worm, *Tœnia saginata*. In a very few cases six suckers have been observed in the place of the usual series of four. There is also a group or variety in which a multiple, or racemose, form is assumed with growth. This variety occurs especially at the base of the brain, and no doubt owes its peculiar form to the absence of the usual cyst produced by the host tissue and to the shape of the place in which it lies.

It is not unusual to find this bladder-worm in the human body. Virchow, in 1866, records it in two per cent. of all autopsies, whereas in 1875, he found it in 1.64 per cent. only. These figures vary, however, rather widely between different localities and on the whole the percentage of occurrence has been reduced considerably within recent decades. In Berlin the frequence in 1882 was only 0.26 per cent. and in 1916 only 0.16 per cent.

As far as the eye and its adnexa are concerned, 174 out of a total of 478 cases reported previous to 1911 from a definite region in the host belong to this organ. When one considers the age of the host these cases arrange themselves as follows: under 10 years, 40 cases; 10-20 years, 34 cases; 20-30 years, 49 cases; 30-40 years, 23 cases; 40-50 years, 22 cases; 50-60 years, 5 cases; 60-70 years, 1 case. It is a curious fact that among infants under ten years, 66 per cent. of the cases were localized in the conjunctiva, and from 10 to 20 years, 64 per cent. of all cases reported concerned the eye. In 580 observations the sex of the patient was noted; 249 of these dealt with the ocular cysticercus, and among these 102 were males, and 147 females. One can observe both generally and among ocular cases a very definite relation to the occupation and method of life. Thus in 89 cases from the eye von Graefe recorded that in 84 the individual lived in close contact with some person following the trade of butcher. The same author, who had seen a large number of cases of Cysticercus of the eye, maintains that the parasite may live in it from two to four years. Saemisch followed a Cysticercus in the eye for ten years. Zulzer describes the case of a family servant in Breslau who showed a Cysticercus in the eye for twenty years. Saemisch relates that in 1865 in Paris in the operating room of a colleague they were visited by an aged invalid who for many years had run around to various ophthalmo-

logical clinics where he allowed the students to examine a lesion of Cysticercus for the modest price of fifty centimes.

In the case of the Cysticercus in the eye the outcome has varied greatly with the point affected. If the bladder-worm is located in the orbit, the lid, the conjunctiva, the cornea, or even in the anterior chamber where extirpation was easy, the outcome has been regularly favorable. When the parasite in question is found in the deeper parts of the bulbus oculi there is more uncertainty. To be sure Hirschberg reports a case where a Cysticercus of the vitreous body disappeared spontaneously at the end of three months. Usually, among 80,000 patients at the eye clinic none was met, but very removed, and in many cases the sight of the eye not only suffers but has been entirely lost.

In individual experience Cysticercus is not common. In a total of 80,000 patients with eye diseases von Graefe reported 90 cases; in Stuttgart one case in 4,000; in Paris one in 6,000; in Copenhagen one in 8,000. Between 1869 and 1885 Hirschberg recorded among 60,000 eye patients in Berlin 75 cysticercus cases, and between 1885 and 1891 out of 46,000 patients only 2 cases, while since 1895 no case has been found there. In Leipzig Sattler saw only 2 in 90,000 cases; from Innsbruck von Herrenschwand reported that between 1900 and 1916 among 80,000 patients at the eye clinic none was met, but very recently two came within a brief period and both were in soldiers.

Among the 807 observations which are quoted by Vosgien (*Le Cysticercus cellulosæ chez l'homme et les animaux,* Paris, 1911) as recorded for a definite location, the eye includes 372 cases, or 46 per cent. of the entire number. Of these, 120 cases are reported from the retina, 112 cases from the vitreous body, 84 cases from sub-conjunctiva, 26 cases in the anterior chamber, 19 in the orbit, 7 on the iris, 2 in the lens, and 2 in the cornea. Hirschberg calls attention to the fact that the Cysticercus seems to have a preferred location in each country for he states it is difficult to explain the preference of the bladder-worm in France for the conjunctiva, in England for the posterior chamber, and in northern Germany for all the deeper parts of the eye.

The large number of cases in which this parasite is found in the retina is noteworthy, and even if such are reported from the vitreous body it may safely be affirmed that in many cases at least this position is secondary, having resulted from the movement of the organisms through the retina and into the vitreous. Von Græfe is of the opinion that the parasite can develop floating in the vitreous but the majority hold that its first appearance is always behind the retina, and it has been seen to perforate that membrane and escape into the humor.

Leber has had opportunity to observe in two cases a bladder-worm at the time when it was passing through the retina. In the first case he saw the specimen when the parasite was two-thirds of the way through, and four weeks later found it free. In the second case the interval was only sixteen days. Numerous other observations confirm this line and direction of movement, whereas there is no evidence to show the reverse conditions.

If lodged in the choroid or retina it presents the appearance of a blue-gray spot which increases in extent and thickness with the development of the parasite. If, however, the macula is occupied, the color is reddish. It has been possible in some cases to observe a slow movement of the animal as well as to follow the characteristic contractions of the bladder. Whether the head of the Cysticercus can be seen depends upon its position with reference to the line of sight.

In the vitreous body the parasite is much more distinct than when it rests beneath the retina. In general it has the appearance of a pale-blue bladder lightly tinted with orange at the margin. If entirely free in the vitreous and devoid of attachment to the retina, it is mobile, and this with the perfect spherical form of the body is adequate for diagnosis. It can usually be shifted so as to show the head and suckers within the bladder.

The presence of the Cysticercus induces changes like those due to any foreign body. An opacity of the vitreous body grows until observation becomes impossible. More or less extensive detachment of the retina occurs and there develops an irido-choroiditis which may lead to a phthisis bulbi, or even to a suppuration that necessitates enucleation. For this series of changes a period of several months usually suffices although one observer watched the scolex through two years without finding it manifest marked alteration, and another (Saemisch) observed a case which went on without trouble for ten years.

More than one Cysticercus in the eye is rare, but Alfred Graefe was able to distinguish in the same patient two bladder-worms in a single eye and both of them were extracted without destroying the form or sight of the eye. Schoebel recorded having seen three Cysticerci in the same eye of an infant of five years.

The first operation for the extraction of a Cysticercus from the eye was done in 1855 by von Graefe, and was successful. The parasite was located in the vitreous. This operation has been performed many times since then, the technique simplified and success assured.

Four cases have been recorded in the United States, the first by Reynolds (*Amer. Pract.*, p. 336, 1874) was a Cysticercus on the pupillary edge of the iris. Turnbull (*Cinc. Med. News* 9, p. 373, 1880) re-

ported a case in the vitreous, Miner (N. Y. *Med. Rec.*, 26, Dec. 26, 1884) another case in the vitreous, and Rembe (*Ophth. Rec.*, Jan. 1907), a Cysticercus of the iris.

Tænia echinococcus von Siebold 1853.—The Echinococcus, or hydatid cyst, is the bladder-worm stage of a small tape-worm found in the dog. When an egg of this tape-worm deposited with the feces and distributed by flies, water, and in dust, or adherent to various objects, reaches the alimentary canal of a suitable host, the embryo escapes, bores in and is carried by the portal system to liver or lung, rarely to other organs, where in time it develops to a bladder of marked size and complexity. The growth is slow; the young bladder-worm measuring only .06 to .07 mm. in diameter 7 days after artificial infection; in 4 weeks it is 0.25 to 0.35 mm. and in 8 it has reached a size of 1 to 2.5 mm. when a central cavity first appears. The slow growth may permit it to go on for months or even years, as in some eye cases, before definite external phenomena disclose the nature of the trouble or even the presence of the parasite.

In a simple bladder which is ordinarily round or oval one can distinguish an external cuticular layer, a parenchyma (endocyst), and a fluid filled central cavity. To such a form, often spoken of as a sterile hydatid cyst, the name of Acephalocystis has been given. Often the organism remains at this stage for a long time—perhaps awaiting some stimulus for the further development noted in most cases. Leuckart says that the majority of hydatids removed from the human host are sterile.

Usually there appear protuberances on the endocyst which develop into brood capsules within the bladder. In such the layers are reversed, the stratified, whitish cuticula being inside and the parenchyma on the surface. These brood capsules may become detached and float around within the primary bladder whereupon the internal cuticula disappears and is reformed on the exterior. Any or all of these daughter capsules may remain sterile, i. e., acephalocystic; more commonly they develop heads by proliferation of the parenchyma layer. On these heads are formed suckers and hooks. By rupture of the brood capsules heads are set free in the cavity of the mother cyst; free hooks are also found in the fluid and these serve to demonstrate on microscopic examination the character of the cyst; however, the absence of both heads and hooks is not evidence that the structure cannot be a hydatid cyst because they are always wanting in the common acephalocystic or sterile variety. The fluid contents of the cyst are regarded by many authors as exceedingly toxic to the host and certain observations support this view very strongly; it is, however, ques-

tioned by other investigators. Great care to avoid rupture of the bladders should be exercised by every operator in view of the serious results of such release of the fluids into the host tissues in some cases on record.

The adult parasite is common in some parts of the world but there is only a single absolute record of its occurrence in North America. The bladder-worm stage is more frequently recorded though some of the presumptive records rest upon confusion with another species having much external similarity; this is *Cœnurus serialis,* the bladder-worm stage of *Tænia serialis.* This bladder-worm is especially common in rabbits of the central United States. The records of meat inspection from various cities in the United States show, nevertheless, that the true Echinococcus is not very rare in some regions.

In man hydatid cysts vary in frequency in different parts of the world. In Iceland 2 to 15 per cent. of the population is infected; in Australia 3,000 cases were reported between 1861 and 1882; in Germany it occurs in 2.5 per cent. of autopsies at Rostock, but only in 0.24 per cent. at Vienna, and 0.01 per cent. at Erlangen. No extensive records exist for North America. It is found in the liver in 75 per cent. of all cases, in the lungs in 8 per cent. and in the eye only in a single case out of 1,800. Thus while the parasite is fortunately infrequent its occurrence in the eye may be rightly regarded as among the most conspicuous rareties of professional experience.

In 1905 R. Greeff published (*Berl. klin. Woch.,* 42, p. 84) a summary of knowledge on the Echinococcus disease of the eye. He had knowledge of some 70 cases in most of which the parasite was found in the depths of the orbit, more rarely in the lateral regions. Records show it also in an optic muscle, within the sheath of the optic nerve, and in the lachrymal gland. With growth it may come to protrude considerably beyond the orbital cavity, or if originally located in neighboring spaces to break down the osseous wall and enter the cavity of the eye. On the other hand it may break through from the orbit into the cranial cavity.

The cases in which the parasite was met with in orbital tissue are not in any way peculiar enough to justify extended discussion. The object makes itself known by its growth and the resultant pressure. Exophthalmus is an evident symptom but no features are noted to differentiate the hydatid cyst from any other cystic growth in a similar location. Such cysts have been taken from the eyelid as well as from the orbit, but are much less common in the external location. It is rare that the cyst is located in the bulb, though it may occur there or in the optic nerve. In the latter place its growth makes it assume

the external character of an orbital cyst, as is shown by an interesting case of recent date.

Papaioannou (*Deutsch. med. Woch.*, 2, p. 1635, Oct. 3, 1907) reported from Athens a case in the optic nerve. In Greece the Echinococcus is not rare but only 0.8 per cent. of cases concern the eye. According to Preindlsberger's summary cases reported from the orbit have been found in the bone or in the soft tissue between the bulb and the wall of the orbit. In this case a youth of 12 from Sparta had at the age of 6 experienced sharp pains in the right eye. The severe inflammation which followed was treated and healed slowly but the vision deteriorated and a marked exophthalmus appeared. When the patient appeared at the clinic sight had been gone for 6 years, the tumor of the orbit covered the conjunctiva bulbi in which the vessels had become very large. Pains in the left eye had begun to appear and pressure from the tumor was becoming serious by virtue of its sudden and marked increase. The character of the growth was not suspected until during the operation it collapsed, yielding fluid and numerous daughter cysts. Part of the cyst wall was firmly adherent to the conjunctiva and part to the lower wall of the orbit. The bladder had developed directly in the nervus opticus and the embryo had undoubtedly reached its location by the arteria centralis retinæ. The location accounts fully for the pains and loss of sight at the start of the trouble six years before the operation was performed.

Two early cases of Echinococcus from the interior of the eye have been much discussed and variously adjudged. The first was given by Geschiedt (Ammon's *Zeit. f. Ophth.*, Dresden, 3, 1833). An inmate of an institute for the blind had suffered in youth from severe ophthalmia in both eyes which was neglected and terminated in total blindness. He died at 24 and when the right bulb was opened, there appeared a delicate fluid-filled cyst; the fluid contained a multitude of small round or oval "worms". No hooks were found. Most critics have rejected the case but R. Greeff makes a strong argument for its acceptance as a positive instance of the occurrence of the Echinococcus in the bulbus oculi. One can not doubt that Geschiedt was a most careful observer and thoroughly familiar with the parasites of the eye. The absence of hooks while the scolices were said to have been developed is the most difficult point to explain for hooks are resistant and there is no other evidence that they ever fail to be formed if the scolices develop.

Griffith (*Trans. Ophth. Soc.*, 17, p. 220, 1897) reported a case which has been criticized and rejected by Kraemer and others though it was undoubtedly correctly diagnosed. A little girl of 4 appeared at the

Polyclinic with one eye blind and presenting the appearance of a cataracta polaris posterior. After enucleation the bulb was sectioned and a cyst found between the hyaloid and the retina. No evidence of daughter cysts, heads, hooks, or other contents could be obtained but others by whom the sections were examined concurred in the view of the author that it was unquestionably an intraocular hydatid cyst. The membrane was characteristically the ectocyst of such a bladder. Sterile Echinococcus cysts are not rare and Leuckart states that in man this form is in the majority.

In spite of these two cases the majority of ophthalmological writers denied the occurrence of hydatid cysts within the eyeball and Kraemer (Graefe-Saemisch *Handbuch*, 2d. Ed., 1899) rejected the evidence in toto. This position is no longer tenable as the following case will show. Nevertheless one must emphasize the extreme rarity of the occurrence.

The first positive case of an Echinococcus within the bulb was published by Werner (*Trans. Ophth. Soc.*, 23, 1903). A healthy farmer, æt. 28, came in December, 1903, to the Dublin hospital; he stated that 7 months earlier with the left eye he could not see at all the upper half of objects and that the eye grew slowly useless. It had been inflamed and painful only for the past month. An examination made evident the presence of an intraocular tumor and enucleation was performed. On opening the bulb the cyst was cut and fluid escaped. The cyst membrane lay close to the entire inner surface of the bulb from the inner face of the lens to the origin of the optic nerve; it was adherent only at one point towards the fundus of the eye. On the inner surface of the cyst wall could be seen the brood capsules of the Echinococcus bladder. When detached and floated in water the cyst appeared perfectly spherical. On sectioning it became clear that the cyst was really sub-retinal. It had evidently originated between choroid and retina in the back of the eye and by growth brought about the detachment of the retina as shown by the defect in vision first appearing over a limited area and gradually extending more widely.

Cases of general Echinococcus disease in the United States and Canada have been collected and published by Osler, Mann, Sommer, and Lyons. The latter (*Am. Jour. Med. Sci.*, 23, p. 124, 1902) lists 241 certain cases, and notes in addition 4 doubtful records accepted by Osler and Sommer. Among all these one finds only a single record of the occurrence of this parasite in the eye or its adnexa. This represents a frequency of 0.4 per cent., which is even larger than European

records indicate although the parasite in general is not as abundant here as on the continent in Europe.

The single North American case came from Austin, Texas, and was reported by Herff.

Sparganum. Larvæ of the bothriocephalid tape-worms are elongate, and worm-like in appearance rather than of the spherical bladder-worm type found in species previously discussed. They are also mobile rather than fixed in position and are found actively wandering through the subdermal connective tissue of the human body. Two species known as *Sparganum mansoni* and *Sparganum proliferum* occur in Japan and both of them have been reported from Florida and Texas by Stiles and by Moore. They produce small tumors on the skin and may easily occur in the eyelids or less often under the conjunctiva.

J. T. Moore (*Trans. Amer. Soc. Trop. Med.*, 9, p. 236, 1914) has collected records of 25 cases, mostly from Japan; there is only one case—his own—from North America. These probably all belong to *Sparganum mansoni.* Among the Japanese cases 8 are from the optic region; this constitutes thus 32 per cent. of the total record, a very high percentage of frequency. In Sato's case from a boy of 17 the larva escaped spontaneously from the corner of the left eye. In Shingu's case, a girl of 15, the worm from the right eye came spontaneously also from between the sclera and the conjunctiva bulbi. Takahashu's case, in a girl of 11, gives the same location though the parasite was excised. Imai reports slight exophthalmos in a man of 33 and removal of the parasite from a retro-bulbar location near the optic nerve. In Miyake's patient, a man of 20, the worm came spontaneously from the conjunctiva, and in his second case, a man of 26, the worm was found between the lower lid and the bulbus oculi in the right eye where it evoked pain and swelling. The frequence with which the worm came out spontaneously in these cases is sufficiently great to create a presumption that this may be its usual method and that the species depends on active migration to reach a new final host. There are no special symptoms associated with its appearance in the eye, and as yet no cases record its presence within the bulbus oculi.

Casaux (*Bull. soc. med. chir. de l'Indochine*, 5, 374, Nov., 1914; rev. in *Trop. Dis. Bull.*, 7:353, June 15, 1916) has reported eight cases of the presence of *Sparganum mansoni* in the upper eyelid. He considers ocular sparganosis, as he names the disease, to be frequent in the Tonkin delta. Pain, redness and lachrymation are associated in this infection with extreme ptosis of the upper lid. On palpation a small indurated nodule as large as an almond, is demonstrated in

the swollen and edematous lid. On cutting the superjacent skin a small mass of yellowish, fatty tissue becomes apparent and in it a minute central cavity enclosing the larval cestode is easily discovered by dissection. Ocular sparganosis is characterized by the presence of *Sparganum mansoni* in the upper lid, by the formation of a fibrous nodule due to the activity of the parasite, and by marked inflammatory reaction in the surrounding tissues.

Two other certain and one probable case of this ocular sparganosis are described by Drs. Gaide and Rongier from the Central Hospital at Hue (Annam). They found that the parasite was not restricted to the upper lid but may be encysted at other points near the eye, as well as of course in other parts of the body. Naturally its intra-ocular occurrence is much the less frequent.

NEMATODA

The Nematoda, or true round worms, constitute a class in which the external appearance is so uniform as to afford a means of ready recognition. They are elongated, nearly cylindrical in form and distinctly monotonous in exterior. Nearly always one finds some taper towards one or both ends, giving them thus a slight spindle shape rather than a true cylindrical form. The surface is smooth, glistening, and colorless; it may be marked by numerous fine striæ but is never jointed or segmented.

The external cuticular layer is non-cellular and very resistant to the permeation of fluids, yet delicate enough to be easily damaged by instruments in manipulation.

As Nematodes are difficult to preserve for study, a few words on technic may be appropriate, especially since errors in diagnosis are unavoidable unless the parasites are kept for study, and because of impermeability specimens are rapidly distorted by transfer from one fluid to another. Those taken from body fluids are best kept for examination in 0.3 per cent. salt solution; tap water is better than distilled water but normal salt solution can be used. This precaution will serve to keep specimens in good condition for temporary examination. They may be preserved best in 70 to 85 per cent. alcohol containing 5 to 10 per cent. glycerine. The fluid should be heated in a beaker over an alcohol lamp until it begins to vaporize, or until it is between 56° to 60°C. with care to avoid setting the fluid on fire. The worms are dropped in as soon as the beaker is removed from the flame. Most forms straighten out at once. Specimens keep well permanently in the mixture and by allowing it to evaporate slowly one can bring them gradually into strong glycerine, if they are not transparent enough for study in the original weak solution.

The lactophenol method is rapid and very good for some purposes but the fluids are not always available. The Nematodes are killed in 2 to 5 per cent. formol and after 2 hours gradually brought into a solution made of 1 part glycerine, 1 part lactic acid, 1 part phenol, and 2 parts water. To get good results about 6 hours are required for the transfer. Specimens can be mounted in this mixture but are subject to constant danger of drying out.

Various species of Nematodes occur as parasites in the human host They are parasitic in the alimentary system, in the lungs, in the kidneys, in serous cavities, in the blood, in lymphatic and connective tissue, in muscle fibres, and not infrequently in the eye. Here they occur as both free and encysted forms in the conjunctival sac, in the tissues of the orbit, or even within the bulbus oculi itself. All of these forms are found only occasionally or in particular geographic areas, but increasing commerce and intercommunication between nations and regions bring the conditions of Europe, Asia, and Africa more and more frequently to the attention of the specialist in our own country. It is evidently of importance to review the cases that have been put on record in order to prepare for the proper recognition and handling of new cases.

I have already called attention to the very uniform and even monotonous external appearance of Nematodes. This is even more striking in the forms which occur in the eye and which belong one and all, so far as recorded, to the group of the Filarioidea, or filarias. On superficial examination they look so much alike that even the scientifically trained observer unfamiliar with this special group is inclined to toss them all into one basket and give them some suggestive and perhaps familiar name. This accounts in full for the number of entirely irreconcilable cases one finds on "Filaria oculi," "Filaria lentis," etc. It is important here to emphasize the fact that despite their apparent similarity in external form these parasites really possess characteristic differences in structure and by proper attention to the earmarks of the species can be classified with desirable precision. Any tendency on the one hand to call them all new and to bestow on them new names with every appearance is quite as far from the mark as the other habit of dumping them all together under some collective designation.

The source of the parasite cannot be determined, and measures for the prevention of its recurrence cannot be formulated, until definite knowledge has been secured as to its precise type. To obtain this information the observer must know pretty fully the structure and life history of some one member of the group, as well as the differences which

separate various species and genera from each other. I have deemed it wise accordingly to select as the type for study and description the widely known and much discussed African eye worm. It has been so carefully studied that one can present a reasonably complete picture of the adult structure and the development to serve for comparison with other less known and less frequent species.

The special attention thus devoted to Nematodes is demanded by the number and variety of these forms which have been listed as ocular

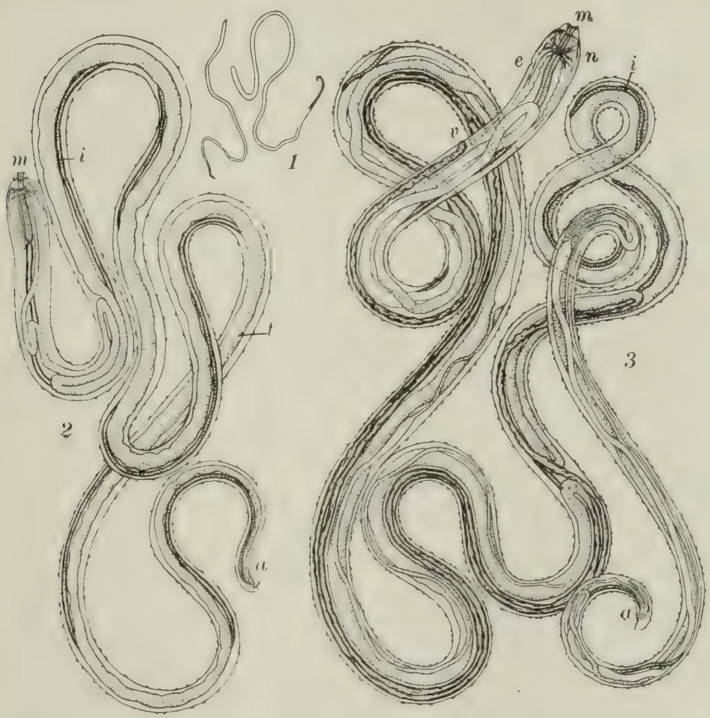


Fig. 4. *Filaria loa.* 1, Male and female natural size. 2, Male × 10. 3, Female, × 10. In 2 and 3 the coils of the body are arbitrarily arranged but the organs are drawn in precisely. *a*, anus; *e*, excretory pore; *i*, intestine; *m*, mouth; *n*, nerve ring; *t*, testis; *v*, vulva.

parasites. It is also justified by the fact that many more references to Nematodes are to be found in ophthalmological literature than to any other group of parasitic animals. Finally the Nematodes are only poorly known and are difficult to handle as well as to interpret so that much confusion naturally exists in this field and a careful description will be helpful to the worker.

The adult Filaria loa (Fig. 4,[1]) has much the appearance of a bit

of catgut or of a violin string. The body is long and slender with a slight difference in caliber which enables one to recognize a thicker and blunter anterior end and a more attenuated and pointed posterior end. The body is semi-transparent and under a strong light one can make out by the aid of a hand lens some features of internal structure. The living worm manifests a peculiar type of movement in a fluid medium which is very characteristic of a Nematode and once seen serves to identify an organism of this type. The movement may be rapid and powerful if the worm is active, or deliberate and even sluggish if a radical drop in temperature, the use of a narcotic, or some other adverse influence has reduced its vitality. In any case this movement consists in a coiling and twisting first one way and then in the reverse direction which keeps the body in constant movement but does not cause it to progress. In longer worms such as the Loa this movement throws the slender body into a complex of coils that is continually changing and on the immersion of the specimen in a killing fluid often results in fixing it in a confused mass difficult to handle and study. Even well preserved specimens show some of these twists in the body form (Fig. 4).

The Nematodes are of separate sexes, but male and female are often difficult to distinguish from each other except on the basis of internal structure. In general the male is distinctly smaller and slenderer than the female. The two differ also in the form of the posterior end which in the female is simple whereas in the male it is hooked or coiled and provided usually, as in this species, with spicules that commonly project from the anal orfice (Fig. 4,[2]) as fine hooks. This end has often been erroneously described as the "head."

The external surface of the body is covered by a transparent, highly refractive membrane, the cuticula, which is non-cellular and reaches a thickness of about 0.01 mm. It is covered with irregularly distributed small scales or warts, widely separated from each other. They have been well described as dew-drop shaped bosses. They are absent on the anterior end in both sexes and the posterior end in the male for a short distance; they are more abundant as well as larger in the female. One does not find here the transverse striation which is a prominent feature in many Nematodes. When present, the striæ appear like fine furrows encircling the body and are separated by short distances only. They do not affect the internal structure at all. Such surface markings are wanting in the Loa, except near the posterior end where, according to some observers, they are present in both sexes.

The longitudinal lines show distinctly in most specimens, especially when the worm is rotated a little. There are four of these, two of them,

the dorsal and ventral lines being median, and two lateral. The latter are much more prominent and in fact are the only ones which can be seen in this species. They appear as narrow pale bands or stripes extending from end to end of the body. The median lines which lie half way between the lateral lines are much finer and cannot be detected in this species except in sections.

The muscles form a layer separated from the cuticula only by a thin layer of granular protoplasm invisible in the entire worm. It is a hypoderm in which one finds nuclei but no cell walls. The layer is expanded at four points into thicker bands which are the structures just described, the longitudinal lines. The muscle cells are powerfully developed and conspicuous under all conditions. One finds exclusively longitudinal fibers that are divided into bands or fields by the longitudinal lines just described. Neither the muscles nor the lines are represented in the figure. In many species of Nematodes the muscle fibrillæ are so numerous and dense as to obscure the organs lying within them; even here they are sufficient to obscure somewhat the view of internal structures.

The mouth opening (*m*, Fig. 4) lies exactly at the anterior tip of the body. It is a simple orifice lined with the inturned cuticula which passes down the alimentary tube some distance. There are neither lips nor papillæ about the mouth but just a little way back near the base of the oral cone one finds in the male two short spines which are not present in the female. The anterior end varies greatly in different Nematodes and is one of the best diagnostic structures of the worm. Lips of various size and shape, papillæ, spines, teeth, and lobes or frills impart to the oral region forms characteristic of different genera and species. There may be no oral cavity or, per contra, this region may be large and highly specialized, as in the hookworm. The observer should note precisely all these points as an aid to the determination of a new species.

The esophagus is 1.1 mm. long in the female but only 0.9 mm. in the male Loa. It appears in lateral view like a double band of muscle fibers, transverse in position and separated by a narrow slit, whereas in fact the lumen is triangular in cross-section and the muscle fibers are, roughly speaking, perpendicular to the inner wall. In the esophagus are gland cells, sometimes large enough to be conspicuous externally. The esophagus ends simply and opens into the long slender intestine without the valves often found at this point. These valves make a bulbous swelling that characterizes many Nematodes.

Crossing the esophagus one notes a sheaf of fibers; these constitute the circumesophageal nerve ring (*n*. Fig. 4). This is the central

nervous system and sends off nerve strands which can be followed some distance but are ultimately lost to view in the mass of other fibers unless they are specially stained. Close to the nerve ring a small incision on the margin (*e*, Fig. 4) indicates the location of the excretory pore. No other parts of this system can be detected without special study. The points *m*, *n*, and *e* are frequently taken for the measurements used in identifying different species of Nematodes so that their accurate location is important.

The simple intestine runs direct to the anus, located close to the posterior tip of the body. This region is always simple in the female (*a*, Fig. 4,[3]) and serves only for the intestinal outlet. In the male, however, it is also the outlet of the reproductive system and has connected with it several special structures (Fig. 5). Two narrow rather thick lateral folds contain large papillæ, doubtless sensory in function. They

Fig. 5. *Filaria loa.* Posterior end of male in ventral and lateral aspects; note especially spicules.

are pyriform with the larger end outside and the first is the largest; they are successively smaller until the last which is the smallest. These papillæ are usually symmetrical but in this species distinctly asymmetrical. The first three pairs are preanal, the fourth and fifth are postanal. Leiper has observed some other small papillæ which need not be described here.

The two spicules cross as they emerge from the cloacal pore. The smaller spicule measures 0.113 mm., and the longer which is strongly arcuate, 0.176 mm. in length. The spicules are unlike in form at both ends. In one the proximal end has a peculiar corrugated appearance on the lateral aspect; this is the place of attachment for the retractor muscle. The distal end of one spicule is bifid and has two minute, sharply-pointed tips; in the other spicule the extreme distal end is rounded, a lateral notch appears on one side near the end and just within the notch comes a short, sharp point. In the words of Leiper who made out these details this spicule is provided at the tip "with an

'eye' like the point of a crochet needle." In cross section the spicule appears grooved like a gouge.

These spicules are easily seen because of their high refractive index, and of the fact that in preserved specimens they usually project more or less from the cloacal pore. They differ in number, length, general form and exact relations to each other in different species of Nematodes.

In other species of Nematodes the narrow, heavy, lateral folds which enclose the sense papillæ near the anus have developed into highly conspicuous wings (alæ) or are in the form of a shallow circular cup (bursa) encircling the tip of the tail. So considerable and characteristic are the structural differences in the tail of the male Nematodes that this region has been seized upon in formulating a diagnosis of the species, and if a male specimen be obtained the determination can be made with precision and promptness but if only females are available much difficulty will be encountered, because of lack of data for differentiating forms generally alike.

The internal sexual organs of the male are extremely simple. They all result from the modification of various regions in a single long tube winding backward and forward irregularly through the length of the worm. As already noted the single pore is common in the male to the digestive and sexual systems. The spicules which project from this pore have their roots embedded in a sac provided with special prominent retractor and extensor muscles; this sac is dorsal to the rectum which just inside the pore is joined on the ventral side by the genital tube. The part of this tube near the outlet is filled with sperm cells and is designated the ductus ejaculatorius; the long slender portion extending through the body as far as the esophagus and back again for some distance is called the testis (*t*, Fig. 4,[2]). The male genital tube ends blindly at the inner end; towards this point it grows constantly more and more slender in caliber.

The female sexual pore is a simple opening (*v*, Fig. 4,[3]) on the ventral surface; in the Loa it is found near the anterior end of the worm. In other types of Nematodes its position is different and may be close to the anterior tip, just in front of the anus, or at any intermediate point. The location of the pore is characteristic of the type. The pore may have thickened margins and be much more conspicuous than in this species. Inside one sees a thick-walled vagina, that some little distance from the pore divides into the bicornuate uterus. This point of division is seen in the figure just where the second coil of the worm crosses under the anterior tip close to the vulva (*v*, Fig. 4,[3]). In the Loa both horns of the uterus are fully developed and terminate

each in a slender thin-walled tube that has near the uterine end a slightly enlarged receptaculum seminis, then a very narrow oviduct and finally a long ovary which tapers to its terminus. The system has thus the form of a Y with long parallel upper branches that are packed in folds extending through the body cavity from esophagus to anus. In other Nematodes one uterine branch may be reduced or even entirely wanting, thus imparting to the female system the single tube plan which as already noted characterizes the male genital system. The uterus is crowded full of developing eggs that near the exit have become well-formed embryos on which the shell membrane is no longer visible. They are ready to be deposited; the Loa is ovoviviparous.

Life history of the parasite. The embryos are discharged from time to time into the subcutaneous connective tissue of the host; they ultimately make their way into the blood stream and are carried in it about the body. Their further development is conditioned upon being drawn into the stomach of some suitable blood-sucking ecto-parasite that attacks the host. In the body of this new, or secondary host, the larvæ undergo certain modifications that preface their reintroduction into the primary or final host when the ecto-parasite bites again. Once that they have returned in this way to a suitable primary host, it requires only a period of growth to produce the adult which develops sexual maturity in due time and starts the life cycle anew. These facts have been fully worked out for *Filaria bancrofti,* the adult of which is parasitic in the lymph glands of man; they are only partially demonstrated for *Filaria loa.* It will be advantageous to go over the life history again to point out certain important details as yet unnoted.

Manson was the first to suggest that the adult Loa was the source of the blood-inhabiting larva that he had called *diurna* because of a pronounced periodicity in its appearance in the peripheral blood. This habit stood in sharp contrast with that of another larval filaria that Manson had observed was abundant in the surface blood at night and was therefore designated *Filaria sanguinis hominis nocturna.* Zoological nomenclature recognizes only binomial specific names and these were accordingly reduced. Finally to all these sexually immature larvæ of which the adults were unknown were given the collective name of Microfilaria and the two species referred to became *Microfilaria nocturna* and *M. diurna.* The former was long ago shown to be the young form of the adult *Filaria bancrofti* and the latter has within recent years been connected with the adult Loa.

These Microfilariæ are difficult to distinguish from each other and it is only by the very recent work of Rodenwaldt and Fülleborn that criteria have been established which are adequate for the purpose.

The accompanying illustration (Fig. 7) gives in half diagrammatic manner the structure of the young larvæ of both species. Despite delicacy and apparent uniformity of structure one can find data enough to differentiate them. Both are relatively large forms with a sheath which in fact is only the greatly stretched shell membrane of the egg. The larva slips up and down within this sheath leaving a clear, unoccupied place now at one end and now at both. When one observes a preparation formed by drying blood on a slide the *Microfilaria nocturna* lies in large rounded curves like metal shavings from a lathe; the extreme point of the tail is free from nuclei and the *G 1*

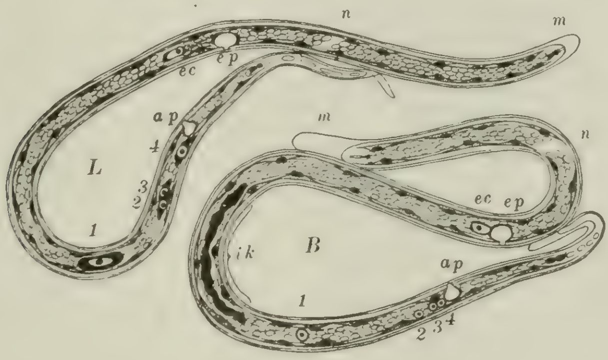


Fig. 7. *Microfilaria diurna* (= Loa, *L*) and *M. nocturna* (= Bancrofti, *B*), Diagrammatic, × 500; *ap*, anus; *ec*, excretory cell; *ep*, excretory pore; *ik*, internal body; *m*, mouth; *n*, nerve ring; *1, 2, 3, 4*, successive cells of which *1* and perhaps others form the later genital organs. After Fülleborn.

cell (*1*, Fig. 7) is relatively small. In *Microfilaria diurna* the position is more iregular, like a wet woolen fiber, the nuclei run clear out into the point of the tail, and the *G 1* cell is very large.

A word with reference to the structure of this larva will call needed attention to that of other species also.

In life the Microfilariæ are colorless and transparent. When present the sheath is clear, thin, and structureless. Various regions, or "spots" as they have been called, stand out above the rest of the organism and are used in making measurements. These points are (1) the middle of the nerve-ring (*n*, Fig. 7), (2) the middle of the excretory pore (ep), (3) the nucleolus of the excretory cell (*ec*), (4) start and end of the so-called internal body (*i k*), if such is present, (5) the nucleolus of the G 1 cell (1) (6) the center of the anal pore (*ap*), (7) the last caudal cell stained by hematoxylin. Fülleborn, who demonstrated this series of points, also showed it was necessary to reduce all items to percentages of total length. The data for the two species

when handled in such fashion give the following average results (Fülleborn), all figures indicating percentage of length.

	Nerve ring	Excretory pore	Excretory cell	G 1 cell	Anal pore	Last caudal cell
M. nocturna	19.6	29.6	30.6	70.0	82.4	95.1
M. diurna	21.6	31.6	36.6	68.6	81.9	Almost at end

Microfilaria nocturna is drawn out from the host into a mosquito as secondary host and its development in the thoracic muscles of that host has been well worked out in the main. When this development is completed, the larvæ desert the muscles and enter the proboscis of the mosquito. Then as the insect bites a second time they force their way out through a thin membrane, bore into the skin of the victim and a new infection is achieved. For *Microfilaria diurna* it was impossible to achieve a transfer experimentally by the mosquito or with ticks, or fleas. Manson conjectured the host must be a day-biting insect and suggested the mangrove flies, which are species of Chrysops and Tabanus. In Calabar Leiper was able to secure experimental development of the embryos in the salivary glands of Chrysops (*Ch. dimidiatus, Ch. silacea*). Details have not been published. Transferred to man from this fly the young Loa develops very slowly, taking 3 to 4 years in some cases in order to reach sexual maturity.

The Nematodes are sufficiently uniform that the description of the Loa will serve to elucidate the general structure of any other of the group. It is wise to consider briefly the various subdivisions of this class. Among the Nematoda are distinguished two orders, the Myosyringata and the Trichosyringata, and in the first, which holds the major part of the species, four sub-orders are well defined, viz., the Strongyloidea, or strongyles, the Filarioidea, or filarias, the Spiruroidea, a recently established sub-order, and the Ascaroidea, or ascarids. In addition to these there is a goodly number of poorly known and peculiar genera that do not allow of accurate placement at present.

To these is joined an artificial group of immature or larval forms that cannot be placed until their adult forms have been identified; this collection is designated Agamofilaria, Agamonema, etc.

The following synopsis presents in proper relation to each other, and to the larger subdivisions, the names of the Nematodes among the parasites that assail directly or indirectly the human eye or its adnexa. Following the synoptic list each species noted is taken up for consideration.

NEMATODA OCCURRING AS OCULAR PARASITES

Scientific name of group: Order	Suborder	Family	Scientific name of parasite
Myosyringata			
	A. Strongyloidea		
		1. Strongylidæ	* Ancylostoma duodenale
			* Necator americanus
	B. Filarioidea		
		2. Filariidæ	Loa loa
			Loa (?) extraocularis
			Filaria bancrofti
			Filaria conjunctivæ
			Filaria circumocularis
			Setaria equina
		3. Dracunculidæ	Dracunculus medinensis
		Unplaced larvæ	Agamofilaria sp.
			Agamofilaria oculi
			Agamofilaria palpebralis Pace
			Agamofilaria eiseni
	C. Spiruroidea		No ocular parasites of man
	D. Ascaroidea		
		4. Ascaridæ	* Ascaris lumbricoides
			* Ascaris megalocephala
		5. Oxyuridæ	* Oxyuris vermicularis
Trichosyringata			
		6. Trichinellidæ	Trichinella spiralis
			* Trichuris trichiura

The genus Loa was established by Stiles to include those filarias with cuticular bosses on the exterior and with large pyriform caudal papillæ in the male in which also the tail is not coiled but only slightly crooked. The single certain species known is the Loa already described in detail. The synonymy of the scientific name and a brief technical description is given next.

Loa loa Stiles 1907
Adult form
Filaria loa Guyot 1778
Filaria medinensis Gmelin 1788 (in part)

* Not parasitic in eye or adjacent tissues but affecting the organ of sight indirectly from a distant location in the body by virtue of general or systematic changes produced. The forms starred are all parasitic in the alimentary canal.

Filaria oculi humani Dujardin 1845
Filaria lachrymalis Dubini 1850 (nec Gurlt 1831)
Filaria oculi Gervais et van Beneden 1859
(nec von Nordmann 1832)
Dracunculus oculi Diesing 1860
Dracunculus loa Cobbold 1864
Filaria subconjunctivalis Guyot 1864
Filaria (Loa) loa Stiles 1907

Larval form
Filaria sanguinis hominis diurna Manson 1891
Filaria bourgi Brumpt 1903
Microfilaria diurna autt

Description: Male 22 to 35 mm. long, 0.3 to 0.4 mm. thick; cuticula without bosses for 2 to 3 mm. at anterior end, and for 1 to 1.5 mm. at posterior end. Anterior end conical, truncate, with two small median papillæ and six minute sessile sense papillæ near mouth. Posterior end tapering, bent 90° or less ventrad in a curve; anus 0.08 to 0.11 mm. from tip; papillæ large, pyriform, slightly asymmetrical, arranged with three pairs preanal and two postanal with small digitate papillæ between 3 and 4 and two small median postanals. Spicules uniform in caliber, grooved, unequal in length (113 and 176μ).

Female: 32 to 50 mm. long, 0.5 to 0.55 mm. broad; cuticula without bosses from 3 to 4 mm. at anterior end, but with same clear to posterior tip. Anterior end as in male with vulva 1.75 to 2.5 mm. from anterior tip. Vagina 9 mm. long with two fully developed uteri and ovarian tubes. Posterior end nearly straight, tapering, rounded; anus 0.17 to 0.3 mm. from posterior tip. Embryos, *Microfilaria diurna,* 253 to 279μ long by 4.7 to 6μ broad.

The adult is parasitic in the sub-dermal connective tissues of man; on occasion it gets into the vicinity of the eye and is the cause of serious discomfort.

The larvæ are found in the lymph and in the circulating blood of man. They do not provoke generally such changes in the tissues as are produced by *F. bancrofti.* No study has been made of the effects they may exert on the retina and the circulatory system in the eye such as are reported for *F. bancrofti.*

The history of the Loa is so prominently bound up with work in ophthalmology for the last 150 years that it is eminently fitting to deal with it in some detail. The "earliest record" is a fable of still more ancient date that is attached to the Loa so firmly as to resist even the most vigorous effort to displace it and because of its widespread ac-

ceptance.* I must discuss it enough to show that in fact it does not deal with this species.

In 1864 Guyon (*C. Rend. Acad. Sci.*, Paris, 59, p. 743) in reporting a case of Loa referred to the existence of a drawing of the XVI Century which represented the extirpation of the Loa. This has been cited by many authors since then, both as the earliest record of the Loa in existence and as noteworthy for its delineation of a surgical operation on the eye at a time and place when such occurrences were certainly very rare.

It was in a book printed in Frankfurt in 1598 that Guyon found a plate intercalated in a description of the Guinea worm (*Dracunculus medinensis*) which in his opinion in one of its scenes portrayed the extraction of a worm from the eye. While no name is given the worm in the text, the location of the parasite he considered full justification for regarding it as the Loa which at first was called the Guinea worm and often confused with it. This record was cited by many later writers and is commented upon in the following fashion by Blanchard (*Arch. parasitol.*, 2, p. 504, 1899): "Le plus ancien document que nous possédions relativement au Loa est une curieuse gravure publiée par Pigafetta, en 1598 (fig. 12). On y voit un personnage qui est en train de s'extirper une Filaire de Médine; un autre Ver, déjà en partie enroulé sur un bâton, sort de sa jambe droite. Un autre personnage subit une opération qui consiste évidemment à extirper la Filaire sous-conjonctivale. Cette gravure peu connue a été reproduite par Jean-Hugues de Linscot, dans le récit de son voyage aux Indes, et interprétée par lui comme représentant la manière dont, à Ormuz, on a coutume de crever les yeux aux parents du roi. Mais cette interprétation fantaiste ne saurait nous arrêter, puisque nous savons que la gravure en question a été publiée pour la première fois dans une description du Congo; elle ne peut s'appliquer à autre chose qu'au Loa, bien que le texte soit muet à cet égard, et cette opinion est précisément corroborée par ce fait, que l'un des individus représentés est atteint de dracontiase.

"Ainsi se trouve établie d'une facon indiscutable l'existence du Loa sur la côte occidentale d'Afrique à la fin du XVIe siècle, exactement un siècle après la découverte de l' Amérique, à une époque où la traite des noirs n'avait pas encore commencé. Cette constatation est importante, puisqu'elle vient confirmer la démonstration que nous avons donnée autrefois de l'origine africaine de tous les cas de Loa observés en Amérique."

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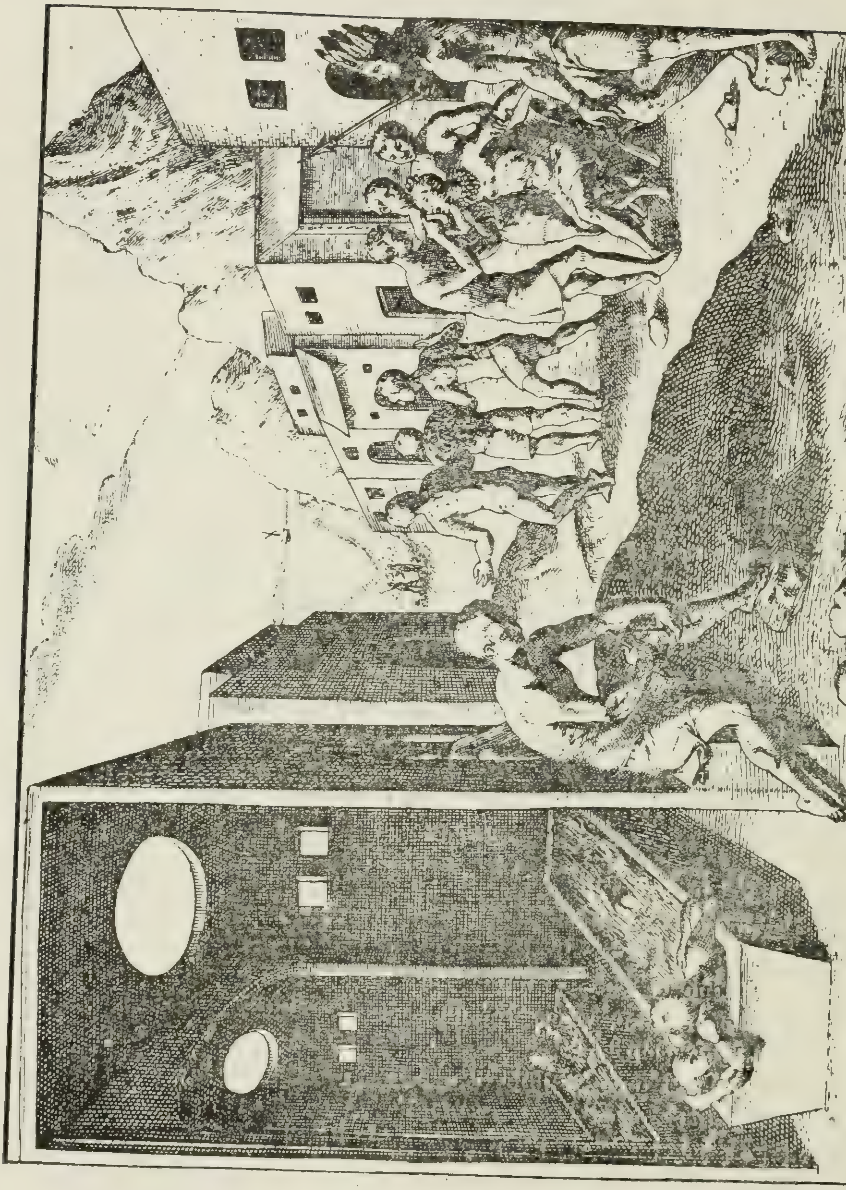
* It is printed in the latest text on the parasites of man and in many good works on the eye to which I have referred.



Reproduction of Jean Linscot's plate 6. For details see text. After Ward from original.

The accompanying reproduction (p. 9302) of the quaint and interesting original will show much justification for the views of the writers quoted above. But unfortunately some other facts have come to light which make it impossible to accept the interpretation given or to regard this plate as evidence of the Loa or of an operation for its removal. A critical examination of the texts on old voyages led to the following conclusions:

Francesco Antonio Pigafetta, an Italian explorer and historian, accompanied Magellan on his circumnavigation of the world in 1519-23, and is the principal authority on this voyage. He died, however, about 1534, and among his works I fail to find any which correspond to that in question. The real author was a Dutch doctor known as J. H. van Lindschoten, or Jean Linscot, as the name is variously written. The editions of his work are exceedingly numerous.

In a detailed description of them under *Collection des Petits Voyages de de Bry*. 1. *Voyages en Orient de Jan Huygen van Lindschoten*'' the plates are listed under letters, a, b, c, d, etc., and the bibliographer notes especially that they lack numerals. The plate under consideration is not listed among those found in this work; it should be noted, moreover, that it bears a number (6) and has no evidence of a letter anywhere on its surface.

The plate does not appear at all in the original Dutch edition of 1596 but is contained in a second part of some later editions. This is entitled *II Pars India orientalis.* From the later English reprint I may cite verbatim the text pertaining to the matters under discussion (p. 46): ''Ch. VI. Of the Island and Towne of Ormus.'' ''And there they have a common custome, that he which is King doth presently cause al his brethren and his kinsmen of the Male kinde to have their eyes put forth[2] which done they are all richly maintained during their lives for that there is a law in Ormus, that no blinde man may bee their king over them.''

Later in the same chapter one finds (p. 52), ''There is in Ormus a sicknesse or common Plague of Wormes,[6] which growe in their legges, it is thought that they proceede of the water that they drink.'' There is no mention whatever of such worms occurring in the eyes.

In view of these facts it is impossible to avoid the conclusion that

[2] ''Teixera (1610) says it is a practice * * * Barbosa mentions this * * * about 1516: * * * The DeBry edition of Lindschoten has an imaginary plate, VI, which includes this.''

[6] I. e., the socalled Guinea worms common in the tropics. The DeBrys give a very imaginary plate to explain this and other matters related of Ormuz, viz., the troughs of water in which people were obliged to sleep on account of the heat, and the blinding of the King's relatives. This plate is not in the original Dutch edition of 1596,'' etc.

the plate undoubtedly concerns the East Indies rather than Africa and the Guinea worm rather than the Loa. On the other hand, it is certainly not entirely fanciful as it shows the native method of removing the Guinea worm with great accuracy. But neither the account of the voyage nor the plate in question can be accepted as a record of the Loa; the earliest notice of that parasite comes nearly two centuries later.

Distribution and frequence. This worm whose antics in the eye are so well known through the descriptions of many observers and especially of the distinguished Scotch ophthalmologist D. Argyll Robertson, was first reported from the West Indies and the adjacent coasts of South America. Only one of the first six cases came from a native of the place, the others being negroes, probably all of them introduced as slaves from Africa. The first published case from that continent appeared in Arrachart's book. How great the interest in these records as they appeared may be judged from the fact that the famous French military surgeon Larry included in his *Mémoires* a long account of a case which had been transmitted to him by de Lassus, army health officer at St. Domingo. Despite the early appearance of the parasite in the West Indies no one has recorded a single case of it either there or in South America since 1845. All but one of these early cases were in negroes and probably the parasite had been brought with the host from Africa, but never gained a footing on this continent unless the single case from a native of St. Domingo is regarded as demonstrating the existence of an epidemic center on the island at that period; if so it must have soon disappeared.

For a long time cases were recorded only from blacks and a certain type of immunity was claimed for the white race, but close upon the first account in 1877 of a caucasian who was infected came many others also. It is impossible now to claim that any racial preference is exercised by this parasite in its choice of hosts. Most cases in Europeans concerned those who were at the time resident in Africa, and almost every other patient offered evidence of having lived there at some previous time. The first case reported in the United States was operated in 1890 by Dr. F. M. Wilson, at Bridgeport, Conn. The second, which was removed by Dr. W. F. Milroy in Omaha, Nebr., was described in 1902 (Ward, *Science*, n. s., 16, p. 250).

The total of 94 cases recorded up to 1906, among which the author listed 8 new from North America, were described in an extended article on the subject by Ward (*Jour. Inf. Dis.*, 3, p. 37, 1906). Two cases in Australia and one in Europe were omitted from that list. All

Americans infected were missionaries who had been in Africa and all of them harbored more than a single parasite.

The analysis of these cases showed them to be widely scattered in time and place and also to bear some relation to a previous residence on the African continent.

Since the date of that summary many more cases have been reported from Europe and America and the general distribution of the worm has been well determined by a large number of observations in Africa. Tropical western Africa, from Sierra Leone to Benguela along the coast, is infected and even as far as Kassai, 600 miles up the Congo. Reports of its endemic occurrence in Uganda are doubtful and probably depend on the introduction of isolated cases.

Even within the natural limits of the Loa, its appearance is markedly sporadic. In certain territory in Old Calabar, French Equatorial Africa and Kamerun it is so common at places that every native and almost all European residents are infected. Nattan-Larrier and Parvu found in the French Congo 110 out of 140 Europeans infected with the Loa. At other points in this region it is said to be represented only by a few imported cases.

Exact location of the parasite. Many times one finds no more definite information than that the parasite occurred "in the eye." This may very likely be interpreted to mean crossing the eyeball beneath the conjunctiva, but outside the cornea or sclerotic. Some authors have in fact given that precise location for the parasite. While this seems to be the most usual position assigned to the Loa it is not its normal seat but probably only an occasional and transient location, as will appear later.

Some accurate records can be cited to show that the worm does occur within the bulbus oculi, even though this be infrequent. The Loa has been removed from the anterior chamber by Mercier, Bachelor and Lacompte. There are no valid records of its occurrence in the lens or in the vitreous although various accounts seek to demonstrate its appearance in those parts, but none of these cases rest on the evidence of specimens removed by operation. Friend has observed that the worm in crossing the eyeball nearly always passes out of view by way of the inner canthus and this has no doubt led to the opinion that it departs through the nasal duct, as stated by Roth.

Most of the positive reports on its location concern positions outside of the bulbus oculi. It has been seen and removed several times from the upper eyelid and from the lower. It has also been observed to wander back into the orbit passing rapidly out of view into the loose connective tissues which occur in that region. Evidently if these

tissues were selected as a more or less permanent resting place it could readily carry out the frequent excursions across the cornea which are described by several physicians as recurring within very brief intervals.

While the worm could generally elude observation in other parts of the body than the eye it was observed in one of the early cases to cross the bridge of the nose from eye to eye. Among the 94 cases collected by Ward were those in which it had been removed from beneath the skin of the back, the sternum, the breast, the lingual frenum, the penis, and the fingers. This was in itself abundant evidence that the parasite did not belong specifically to the eye, but was rather a migrant through the subcutaneous connective tissues. This view was established by Penel (*Arch. parasitol.*, 9, p. 187, 1904) at an autopsy of a Congo negro who died in Paris of sleeping sickness. More than 30 Loas were found in the superficial connective tissues of the four appendages and not one could be discovered in the neck, face, head, or region of the eye. As a matter of fact the forms taken from the eye are usually small, immature, or half grown, and represent a youthful migratory state. The much larger adults occur almost only in the superficial connective tissues, usually of the appendages.

An interesting clinical picture of *F. loa* comes from the observations of the French physician Lota who studied the action of the worm in his own eye and whose account in brief runs thus: After his stay in Gaboon and return to France, Lota suffered oft-recurring conjunctivitis with which he was not previously afflicted. Suddenly he felt in the right eye a sting without outward cause, and a feeling of heaviness which was unpleasant, while at the same time there arose an active injection of the conjunctiva bulbi. These symptoms disappeared on application of cold lotions to the eye, but recurred in a few days. Lota attached no importance to the matter. Several months after his return he was awakened from sleep one morning by a sharp pain in the right eye. He had the sensation of a foreign body under the upper lid, accompanied by frequent winking. As he drew up the upper lid before a mirror, he noticed the conjunctiva was reddened, swollen, and slightly elevated. He recognized under it a yellow, irregular mass without being able to determine its nature. The sensation of a foreign body lasted about two hours and then ceased suddenly. Lota investigated the eye again and could determine only a slight conjunctivitis: the yellow body was gone!

That evening the same symptoms came on again. Lota noted on the sclera a yellow, round body of the caliber of a knitting needle, about 2 to 3 cm. long, which moved itself from the external angle of

the eye towards the caruncle, at times straight, again bending itself into U and S shapes; it crept along under the corium above the sclera only to disappear at the inner angle of the eye. Next evening the worm showed itself under similar circumstances below the conjunctiva above the cornea; here it remained a long time so that several colleagues of Lota could observe its presence and movements. It then disappeared again into the depth of the eye and never appeared thereafter. Its presence had induced no further change on the bulb than an insignificant elevation of the connective tissue. The visual power was never disturbed.

Another account given by an English physician Rogers (*Ann. Trop. Med. and Hyg.*, 7, p. 363, 1913) includes some further valuable data. He was in Lagos in 1908 and experienced fugitive (Calabar) swellings late in the following summer. In November 1909 he recognized a Loa crossing the bridge of the nose, and since then had not been free from signs of its presence. His account continues thus: "When the parasite appeared on the face I was generally made aware of its presence by accidentally feeling a spot that was tender on pressure, say, in the lower jaw; later on, in an hour or two, that part was swollen but the tender spot had passed upwards towards the eye, always leaving in its wake an edematous track. I noticed that invariably when it appeared on the face it made its way towards one or other eye; it generally made two or three tours round the eye, either in the lid or under the ocular conjunctiva, and then crossed the bridge of the nose to the other eye; in the region of the eye it was always visible under the skin. After visiting the eye it would wander over the scalp, its curve being easily traceable by the tender area and, later, localized swelling. The next day possibly, I would feel nothing further, and so for several weeks; or, on the other hand, I might wake up with a swelling in a leg or arm; in this case it is impossible to say whether it was the same worm or no, as it was later shown that I had at least two parasites. The presence of the worm in the eye was always accompanied by a pricking, boring pain; when under the conjunctiva it caused severe conjunctivitis with redness, dilated vessels, feeling of grit, headache, etc.

"On one occasion a cutting operation was attempted without success; on another, an injection, likewise without success, of 1/1000 mercuric chloride. After these attempts it disappeared for several weeks. Towards the end of 1912 (about October, I think) a worm was removed from under the conjunctiva, on which you kindly reported, describing it as an immature female. After this there were no more ordinary, usual symptoms for some time. In December, 1912, I developed

'mumps,' and was accordingly isolated; in the light of later knowledge I have no doubt that this was caused by the second parasite. After that I had rest until a month or two ago, when, after the prolonged hot weather, the old signs reappeared, but in an exaggerated form. A swelling would appear in a limb, at first localized (exactly like a lipoma) but later on (a few hours) firm, brawny and, for the first time, red, looking like a cellulitis. The limb (arm or leg) would be quite elephantoid; on one memorable occasion the thigh was so swollen that I was unable for several hours to put on my trousers. On that occasion the parasite, if it was the same one, had been seen in the eye the previous day. The swelling would be totally gone in a day or two. When it appeared in the eye it would leave that organ swollen and closed, giving me a 'drunk and disorderly' appearance; that, with the accompanying headache and woebegone look, were likely to give rise to unwarrantable suspicions detrimental to my character.

"A second worm now in your possession, was removed in the middle of August, 1913."

Laveran (*Bull. soc. path. exot.*, 9, p. 436, 1916) has described a case in which an infection with the Loa lasted 14 years.

With regard to symptoms mention should be made of the constant presence of a marked eosinophilia. The discomfort and even distress experienced are commented upon by many observers; also the fact that the cutaneous symptoms vanish with a drop in temperature or on the other hand are increased in hot weather.

Various therapeutic agents have been tried on the embryos of this parasite with little or no effect. e. g., atoxyl, thymol, methylenblue arsenophenylglycin, and salvarsan. In some cases an injection of 1 cc. of one tenth of one per cent. solution of corrosive sublimate has been successfully employed to kill the adult worm, after which it has apparently been absorbed gradually. When its presence in the eye has become objectionable, its removal has been easily and successfully accomplished by numerous operators. It should be noted that the troubles may recur unless the host shelters only a single parasite, which is not the rule. X-rays have also been tried.

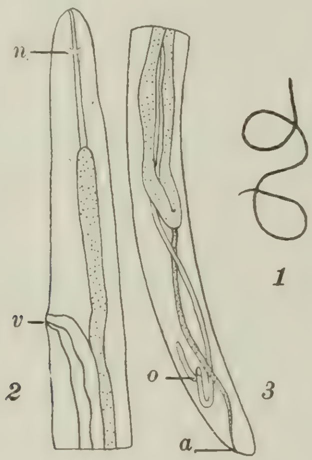
Ziemann suggests painting a collodion ring to retain the worm in a narrow area, and others have used cocaine or adrenalin to make it visible and thus favor its removal through a small incision. It should be recalled that the adult does no damage to the eye and that in most cases its wanderings are terminated in a short time after which the host is unconscious of its presence.

Loa (?) extraocularis Skrjabin 1917.

The worm was reported last year as a new Nematode parasite from

the human eye. Skrjabin who described it (*Compt. rend. soc. biol.*, Paris, 80, p. 759, 1917) received the specimen from Dr. A. P. Wladytchensky, of Ekaterinodar (north of Caucasus).

Description. Single specimen (see Fig.) a female 143 mm. long, not fully mature. Cuticula finely striated; no bosses. Both ends rounded, the anterior with 2 lateral and 4 sub-median papillæ; no lips. Anterior end larger than posterior. Maximum diameter 0.61 mm. just behind vulva about 2 mm. from anterior tip. Esophagus 0.935 mm. long by 0.085 mm. broad. Vagina with double uteri, oviducts and ovaries; Neither eggs nor embryos found. Anus 0.1 mm. from caudal tip; two lateral, postanal papillæ.



Loa extraocularis, female; *1,* natural size; *2,* anterior end, magnified; *3,* posterior end, magnified; *a,* anus; *n,* nerve ring; *o,* ovary; *v,* vulva. After Skrjabin.

The host was a peasant girl, 21 years old. The parasite was taken from a tumor located at the internal angle of the right eye between the wall of the orbit and the eyeball. The tumor was as large as a bean, mobile, resistant, unattached and painless. It had not interfered with the movement of the eye. On opening the tumor a slender active worm was found surrounded by a fibrous capsule. The wound healed by first intention.

The parasite is much like *Filaria conjunctivæ* (q. v.) except in the position of the vulva and of the nerve ring. It departs radically from the definition of the genius Loa (q. v.) as given by Stiles since the non-striated cuticula with bosses was emphasized in the diagnosis of that genus. The case is isolated and probably represents an erratic indi-

vidual of some species normally in a large mammal of that region. Until new material is obtained its proper name and place cannot profitably be discussed; meantime it is left in the position to which its discoverer assigned it.

Filaria bancrofti is a species that is widely known as a human parasite in tropical regions. The adults live in lymphatic glands and the larvæ (*Microfilaria nocturna*) produced in enormous numbers, swarm at night in the superficial capillaries of the body. This larval form (Fig. 7, M) has already been described and compared with the young of the Loa which it closely resembles except in periodicity, its appearance being directly contrasted with that of *Microfilaria diurna* (q. v.). Recent studies have demonstrated the necessity of treating *Filaria bancrofti* as an ocular parasite not because of the adult but by

Section through a pterygium of an otherwise normal eye. Microfilaria in hypertrophied connective tissue. Magnified. After Leber.

reason of the influence of the larval forms in the circulating blood on the retina and the visual powers of the eye. The general character of filariasis and the permanent changes seen in elephantiasis are well known and it is not surprising that the eye and its adnexa should share in the pathologic changes due to this infection. In one case of true elephantiasis Lewis has seen chyle containing microfilariæ discharged from both conjunctivæ. This is, however, rare.

Abundant ophthalmological material has been brought under careful observation within recent years in Samoa where *Filaria bancrofti* is exceedingly abundant and it appears that the effects are as clear and as manifold in the eye as in other parts of the human organism. In Samoa at least 60 per cent. of the population show marks of the disease and probably every native has been infected with the filaria at some

time or other during life. To produce the permanent conditions of elephantiasis it apparently requires repeated inflammatory tumefactions; such swellings arise regularly following infection by mosquito bites after an incubation period of six weeks. The organism which produces these is in all respects like *Filaria bancrofti,* except that, as Fülleborn has shown, it is not periodic. The extraordinary numbers of these larvæ which are found in a single host must purely mechanically retard the lymph flow and give rise to lymph stasis which is further increased by the secondary inflammatory processes until the tissues come to be enlarged.

Leber (*Arch. f. Ophthalm.*, 87, p. 541, 1914), has made on the ground the most careful observations of modifications in the eye produced by filariases. First of all he notes inflammations of the lids in which at times edematous swellings appear precisely as in the skin of the appendages and in the sexual organs. These tumefactions appear suddenly and are accompanied by reddening and twitching of the eyes, with headache. The phenomena are confined to the lids themselves and disappear in a few days without leaving any apparent effects. However, here, as elsewhere in the body, relapses are not rare and it appeared to this author likely that repeated inflammations probably furnished the explanation for the rare cases similar to blepharochalasis in which one finds the skin of the upper lids pendant and very loose without adjacent tissues really being altered or thickened.

Earlier, Ziemann (*Dtsch. med. Woch.*, 1905) has described elephantiasis of the eyelids in Africa and changes of similar character had been reported from other tropical regions. Lewis saw in one case a chylous fluid loaded with microfilariæ flow out of the conjunctival sac of both eyes. Leber and Prowazek demonstrated microfilariæ in the conjunctival fluid and also in microscopical sections of the little modified conjunctiva.

Pterygia (moalili tautau) are extremely abundant among the Samoans even in otherwise normal eyes, and Leber demonstrated the frequent occurrence in them of microfilariæ even outside the blood vessels. The pterygia in extent and thickness often far surpass those seen in Europe; on miscroscopical examination they appear to consist in greater part of loose hyaline modified connective tissue fibers in which microfilariæ were enclosed (p. 9310). Conjunctival cysts filled with a fluid fatty substance were also present and attributed by Leber to the filarial affection. He observed further that these pterygia are without antecedent corneal ulcers, that they grow over the cornea from the temporal as well as the nasal side, and that they appear in eyes where the conjunctiva is normal.

Leber observed even more serious though not unexpected changes in the interior of the eyeball in the shape of diseased conditions of the choroid and retina of a type evidently due to mechanical interference with the circulation. Obstructions were in evidence both in arterial and in venous canals. Comparison of measurements showed clearly that microfilariæ can produce stasis in the retinal vessels and thus affect seriously the nourishment of the area served by these vessels. The immense numbers of these larvæ must be quite as important in this connection as their size.

In both choroid and retinal vessels Leber observed (Fig. 11) miliary emboli and thrombi, yellowish-white plugs which at points interrupted

Fig. 11. Right eye in case of severe filariasis with thrombosis and hemorrhages. After Leber.

the blood current and made the vessels at the margin appear empty and reduced in caliber. Near such points he found centers of degeneration that had evidently arisen by fusion of similar smaller areas. The periphery appeared on the whole more affected than the central portion but even the macular region was diseased in one case, and naturally in this the power of sight was most seriously affected. Hemorrhages also were not rare; they were distinguished from those that appear in ancylostomiasis by their extent and irregularity.

In one case Leber tried phenocol treatment which he had found useful in general filariasis and succeeded in achieving distinct improvement in vision, probably by bridging over a short vascular obstruction.

Filaria conjunctivæ Addario 1885 (Fig. 12).

Syn.: *Filadia palpebralis* Pace 1867 (nec Wilson 1844). *Filaria peritonei hominis* Babes 1880. *Filaria inermis* Grassi 1887. *Filaria apapillocephala* Condorelli-Francaviglia 1892.

Only the female of this species is known and it appears to be a normal parasite of the horse and ass that has found its way in certain cases into the human host. It has been confused with other forms, especially *Setaria equina* of which the immature form has been reported from the eye of the horse under the name of *Filaria labiato-papillosa.* The adult *Setaria equina* lives in the peritoneal cavity of the horse and ass. It is possible that these cases of supposed *Setaria equina* belong in reality to *F. conjunctiva.* I have regarded the form known as *F. palpebralis* of Pace 1867, which is not the *F. palpebralis*

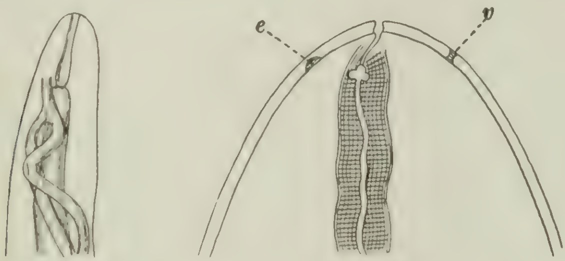


Fig. 12. *Filaria conjunctivæ,* anterior end of female; *a,* with esophagus, intestine, and uterus; *b,* tip of body with excretory pore (*e*) and vulva (*v*). Addario's specimen. After Braun.

of Wilson 1844, as actually a young form of this species. The same interpretation has been placed by some authors on *F. oculi humani* of von Nordmann 1832. The last two forms are properly classed under the name Agamofilaria since they are immature forms. The brevity of the description and the lack of striking features of structure in the Nematodes makes it impossible to reach a final decision in these cases. Such larval stages are very much alike and all the evidence at hand is not adequate for a positive determination. Doubtful cases reported in Italy and Southern Europe, where this species is endemic, are naturally assigned to it. No evidence at hand enables one to say whether the Asiatic cases referred to are the same or a different species.

Description: Male unknown. Female 160 to 200 mm. long, 0.48 mm. broad, whitish or brownish in color. Cuticula without papillæ or bosses, finely striated transversely and marked by longitudinal striæ also, except just at anterior end. Mouth without lips or papillæ. Esophagus 0.6 mm. long, not armed. Anus 0.3 mm. from posterior

tip, followed by 2 gland cells. Vulva within 0.1 mm. of anterior tip. Eggs hatch in uterus; embryos 0.35 by 0.0055 mm.

The life history is unknown, but Alessandri has conjectured that it is transferred to its final host by *Chrysops cœcutiens.*

The first case reported from man was observed in Milan (Italy) by Dubini in the eye; the worm was 115 mm. long.

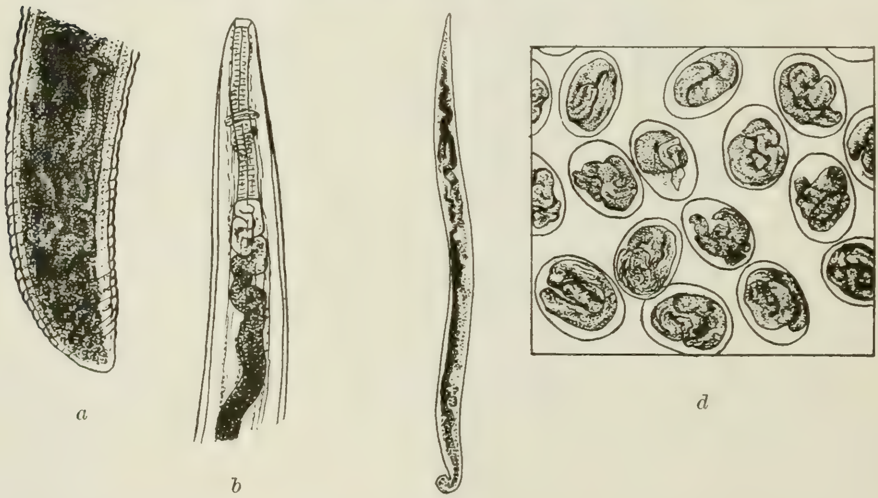
In 1885 Addario (*Ann. d'ottalmol.,* 14, p. 135) described a case in which a growth the size of a pea was removed by Vadela from the conjunctiva bulbi of a woman in Catania (Sicily) and was found to contain one of these worms 95 mm. long.

Other cases concerning the same species record its removal from parts of the human body not related to the eye.

Filaria (?) circumocularis (see Fig.).

Syn.: *Filaria palpebralis* Houghton 1917 (nec Wilson 1844)

This interesting parasite was brought on the stage very recently by



Filaria circumocularis; a, posterior end of female, × 64; *b,* head, × 64; *c,* male, × 9; *d,* embryos in egg shell, × 256. After Houghton.

two records of its occurrence in man and a third from the dog. All these are from China. Houghton (*China Med. Jour.,* 31, p. 24, 1917) who studied the specimens inclined to identify them provisionally with *Thelazia lacrymalis* (=*F. palpebralis* of Wilson) which is parasitic on the conjunctiva of the horse in Europe. This identification can hardly be accepted because of prominent structural differences in the descriptions. The true *Thelazia lacrymalis* is also an European species that thus far has not been reported from the East.

Description: White (pink in life), delicate, attenuated slightly towards both ends which are bluntly rounded. Cuticula coarsely striated. Mouth terminal, small, neither lips nor papillæ. Male 9 to 10 mm. long. Four preanal papillæ; small postanal projection. Female 14 to 15 mm. long, larger and heavier than male. Vulva close to anterior extremity. Uterus filled with eggs containing embryos.

The worms from the dog were distinctly smaller as the male measured 6 mm. long and 0.3 to 0.5 mm. broad; the female was 10 to 12 mm. long by 0.8 mm. broad.

The first case was reported by Stuckey (*China Med. Jour.*, 31, p. 24, 1917) at Peking. A Chinese male servant 25 years old appeared at the eye clinic saying that since the preceding summer there had been worms in his right eye and showing one in a bottle that had been removed two days before. The second very careful examination disclosed in the upper fornix an almost invisible moving body on the conjunctiva. After the use of cocaine 4 white threadworms were removed.

The author adds a record of the occurrence of similar worms in a pet dog at Tungchow.

A second case was reported by Trimble (*China Med. Jour.*, 31, p. 266, 1917) of a Chinese farmer who came to the Fukien hospital. The record of the case is as follows: "Three months previously he had noticed a pain or ache in his right eye, slight at first but becoming worse and worse, until at the time of coming to us he was in great discomfort. Shortly after the onset of the pain he noticed that he had an excessive flow of tears, and for the last month he had been unable to close his eye completely.

"The most striking thing noticed upon superficial examination was the severe ectropion of the right lower lid, which was more of a sagging away of the lid than the usual type of ectropion. This allowed the constant flow of tears to run down over his face. Further examination revealed that this sagging away was due to a more or less complete facial paralysis of the right side. There was only a slight conjunctivitis and we were about to dismiss the man as an incurable case of facial paralysis when a more careful inspection of the conjunctival sac brought to light, in the superior fornix of the right eye, two small worms. They were decidedly active, pink in color, and easily distinguished from the slightly congested conjunctiva. They were easily removed and further search for others in both eyes proved fruitless. The worms are females of the same species as that described from Dr. Stuckey's patient, by H. S. Houghton. The patient's blood, urine, and stools were examined by me and nothing special noted.

"Upon removal of the parasites the man had immediate relief as

far as the pain was concerned. We had him under observation for about three weeks, during which time the epiphora disappeared and the muscle tone in the paralyzed area was restored to at least 50 per cent. of the normal."

Setaria equina, better known as *Filaria equina* is a frequent parasite of the Equidæ. It occurs there in the abdominal cavity. Its sole right to consideration is the following very doubtful account: Brockman Drake (*Ophth. Rev.*, London, 13, p. 331, 1894) reported a filaria from the eye of a young woman in Madras, India. The worm escaped through a puncture and was not studied. While the author regarded this as a Loa it is hardly likely since that parasite does not occur in India. Blanchard regards the worm as probably *F. equina*, which is common in India as a normal parasite of the horse.

In a letter from a mission hospital in Kashmir, Neve (*London Lancet*, 1, p. 446, 1895) reported *F. loa* from the anterior chamber of the eye of a horse. This also is much more probably *F. equina*.

Dracunculus medinensis (= *Filaria medinensis*) is the Guinea worm, known historically as the fiery serpent that plagued the children of Israel during their wanderings in the desert. It is a frequent parasite of man and higher mammals in certain regions. The older literature contains many references to its occurrence in or about the eye. No one of these cases which I have been able to follow up shows evidence of the correctness of this diagnosis. Most of them clearly refer to the form now known as the Loa which was at first confused with the Guinea worm. Guyot in 1777 was the first to distinguish the two species and give the Loa an independent position. Despite his careful differential diagnosis other observers of later date continued to regard the Loa as a young, or half-grown Guinea worm. This confusion has been incorporated into works on the eye even within relatively recent times. It is altogether probable that the Guinea worm must be eliminated from the list of human parasites that even occasionally visit the eye or its adnexa.

Agamofilaria. The name is employed to include all those sexually immature Nematodes belonging to the group of the filarias, or Filarioidea, which because of the absence of diagnostic features or of the scantiness of the original description cannot be assigned to a definite genus. Most of the names employed are merely convenient collecting places for worms of somewhat similar character that may or may not be alike in fact.

Agamofilaria oculi Stiles

Syn.: *Filaria oculi humani* von Nordmann 1832; *F. oculi* von Siebold

1839, nec *F. oculi* Clarkson 1845 (of horses); *F. lentis* Diesing 1851.

A number of cases from the human eye have been reported that are not distinctive. It seems wise to throw them together under this heading. They are all immature or larval worms of different size but without diagnostic features in the description given. Some of them came from the anterior chamber, some from the body of the lens, and some from the posterior chamber. Such differences in location are not of particular significance in determining the character of the worms.

All cases which depend merely on descriptions made with the ophthalmoscope and are unsupported by evidence furnished by an operation and a subsequent study of the specimen have been uniformly rejected by parasitologists as inadmissible for reasons already stated.

The earliest cases observed by Mercier in 1771 and 1774 at St. Domingo, were published by Arrachart (*Mem. sur les vers des yeux*, Paris, 1805) without name. The description leaves little doubt that these really concern the Loa and should not be considered under this heading. Numerous other records of *Filaria oculi* are of a similar character and may properly be assigned to *Filaria loa*, even though the authors by failing to recognize their true character assigned them this undeterminate name.

In von Nordmann (*Mikr. Beitr. zur Naturges. d. wirbellosen Tiere*, Berlin, 1832) is given a good account of two cases operated on by von Graefe for *cataracta lenticularis*. The first case, a man, had both lenses removed and the lenses came into von Nordmann's hands within half an hour. In the center of one lens were two small Nematodes, one of them damaged. The length of the other was 12.5 mm., it was coiled in a spiral and dead when examined. In a lens removed from an old woman a year later was a living filaria 13.2 mm. long in process of molting.

A little later Gescheidt (*Zeitsch. f. Ophthalmol.*, 3, p. 405, 1833) found in a single lens removed for cataract, three similar worms. Although these three cases occurred within a brief period in Europe there has been no subsequent evidence to indicate the existence of a species there which was likely to infest the human hosts.

In San Francisco, Barkan (*Arch. Ophthal. and Otol.*, 5, p. 15, 1876) was consulted by a native Australian with bad eyes; a whitish, thread-like foreign body was seen adherent to the lower part of the iris in the anterior chamber of the left eye. It was removed and on examination declared to be *Filaria medinensis*. This is difficult to accept as the patient had never lived in any territory infected with that parasite. Moreover it is doubtful whether *F. medinensis* ever enters the eye. Neither can it be regarded as *F. loa* which is also unknown in the re-

gions where the man had resided. Perhaps it was an unknown Australian species. It must be left here among the undetermined forms.

One case studied with the ophthalmoscope merits further mention Kuhnt (*Arch. f. Augenheilk.*, 24, p. 205, 1892) detected a small filaria in the eye of a patient, followed its gradual growth through a considerable period and later extracted it by an operation. It was only 0.38 mm. long and immature so that more precise determination of the species was impossible.

Agamofilaria palpebralis Pace 1867 (nec Wilson 1844). Pace found in the subcutaneous tissue of the eyelid in a nine-year-old boy of Palermo a small filaria which is too inadequately described to locate it in a known species. It was under the skin in a cyst filled with a dense fluid like the white of an egg. The author named it *Filaria palpebralis.*

The species to which Wilson first gave the name *F. palpebralis* is parasitic in the eye of the horse. This is not the same as the form reported from man and the name given by Pace is evidently preoccupied. Grassi conjectures that Pace's specimen is an immature individual of *F. conjunctiva.* I have also assigned it to that species.

Agamofilaria eiseni. On his return from an expedition to Mexico and Central America Eisen described (*Am. Jour. Ophthal.*, 11, p. 111, 1894) a remarkable disease of the eye known as "mal de ojo," prevalent along the coast during the hot months. The cause was said to be a small gnat or fly depositing ova or young on the eyes, chiefly of the poor and of children. Eisen counted 25 flies on the lids and conjunctiva of a single infant. The disease is confined to the mucosa and runs 6 to 8 weeks. It starts with a slight redness of the conjunctiva which spreads rapidly. Within a few days a muco-purulent secretion flows from between the lids. The muscles of the body become sore; the children lose appetite and become stupid. The lids are greatly swollen and everted; the mucosa is dark-red and thickened. Particles are thrown off now about an inch long and thread-like; these are young filariæ which apparently are not alive when removed. The victim gradually assumes a normal appearance and the eyes recover fully.

Doubtful form. De Mets (*Belgique Med.*, Gand-Haarlem, 1, p. 737, 1896) under the title of *Filaria in the Retina* reported a Nematode observed in Belgium in the urine, which he neither described nor identified. General symptoms led him to infer the presence of these worms in the retina. This was not demonstrated in any other than an inferential fashion and has not been confirmed for Europe though the microfilariæ of the blood have been shown to produce serious changes in the retina (Cf. account of *Filaria bancrofti*).

Ascaris lumbricoides, the common stomach-worm of children, is sufficiently frequent to be known to any practitioner; yet from its normal habitat it seems hardly likely to come directly under the designation of an ocular parasite. However, in one instance Haffner (*Berl. klin. Woch.*, 17, p. 346, 1880) reported that a child a year old with whooping cough was brought to him. A 3 cm. long bit of an ascaris was hanging from the left eye. The worm had undoubtedly been vomited into the nares and had wandered through the inferior lachrymal sac into the lower lachrymal point in which it was so tightly enclosed that some effort was needed to remove it without tearing.

This species is known to exert a toxic influence on the eye which though much less violent is similar to that exerted by the next species. The most serious effects are produced by chance injection of the cœlomic fluid into the eye. Thus two cases are reported in which a butcher while preparing meat by chance cut into a specimen of this worm and spurted the cœlomic fluid into his eye. Active inflammatory processes ensued. This, which is a form of acute connective tissue inflammation, has been denominated ascario-conjunctivitis. A much larger number of cases has been reported for the next species in connection with which the malady is more fully discussed.

Ascaris megalocephala, the round-worm of the horse, is a large nematode much used as a laboratory object; it yields especially favorable material for the study of cytology so that it has been much sought after by investigators. Even before it became so highly prized for special purposes its unpleasant effects were known. Bastian (*Philos. Trans. Roy. Soc.*, London, v. 156, 1866) recorded his extreme susceptibility to this species while at the same time he was apparently immune to *Ascaris lumbricoides*. The sensitiveness to *A. megalocephala* increased with time until the slightest contact even with material preserved in alcohol for two years, or even if macerated thereafter in calcium chloride for several hours, evoked the severest symptoms.

The malady is general in its effects but has special relations to the optic organ that may be mentioned here. Those who come in contact with these parasites are mostly scientific workers and the complaint may be classed with propriety as an occupational disease. To it have been subjected some of the most distinguished scientific workers in the zoological field, Bastian, Cobbold, Huber, Leuckart, Railliet, Goldschmidt, Zur Strassen, Boveri, and others. A few manifest total indifference to the influence and work over specimens at short range without any results whatever; and on others the effects are variable though regularly noticeable. In general first attacks are mild and the growing susceptibility described by Bastian seems to conform to

the average experience. He writes of the symptoms as follows: "I first examined this species in the spring of 1863, when certain strange effects were produced which I was enabled to trace absolutely to the fact of my working with this animal. These were a greatly increased secretion from the Schneiderian membrane, with irritation of it, causing continuous sneezing, also irritation of the conjunctiva, with such a sense of itching about the eyelids and caruncula lachrymalis as to make it extremely difficult to abstain from rubbing them. When they were rubbed this immediately gave rise to a swollen and puffed condition of the eyelids, swelling of the caruncula, and extreme vascular injection of the conjunctiva, and if the rubbing was at all persisted in, actual effusion of fluid would take place under the conjunctiva, raising it from the subjacent sclerotic and cornea. A few minutes would suffice to produce these serious effects upon the eyes, but after a little bathing with cold water, and rest in the recumbent position for a couple of hours, they would have again resumed their natural condition. At the same time that these effects were produced upon the mucous membranes, the skin of the face and neck was also affected, so as to cause a sensation of itching something similar to what exists in a mild attack of nettle-rash. If I continued to work for about two hours in spite of these symptoms, a general feeling of lassitude and weariness was produced, sometimes amounting to an actual sense of prostration, which would, however, all pass off on desisting from the work and lying down for a few hours. After a few weeks another symptom was superadded, in the form of an asthmatic difficulty of breathing, owing apparently to a constriction of the trachea and of the larger bronchial tubes, which was first noticed about one o'clock one night shortly after going to bed. Without any warning I felt a kind of constriction of the upper air-passages with great difficulty of breathing, each inspiration and expiration being accompanied by an almost musical, wheezing sound. This lasted for about three-quarters of an hour when there came a gradual relaxation of the spasm, and all was well again. Such attacks as these gradually became more frequent, generally occurring in the night or evening, lasting longer and often associated with a spasmodic cough, so that much against my inclination I was at last compelled to abstain from any further examination of these noxious individuals. My system at length became so sensitive to the emanations of this animal that I was even unable to wear a coat which I had generally worn during these investigations, without contiually sneezing and suffering from other catarrhal symptoms. Avoiding this and other sources of irritation, after a period of about two months every vestige of these symptoms had dis-

appeared, and continued absent till May, 1864. During this interval I had never looked at a specimen of *A. megalocephala,* neither did I once experience any of the old asthmatic difficulty of breathing. For one day in the beginning of May I did work with this animal again; not so much sneezing and actual irritation was produced at the time, and I was full of hope, but in the evening came one of the old asthmatic attacks, and the influence produced by this one day's work did not completely exhaust itself till the middle of June—a period of nearly six weeks. During all this intervening time I had been subject to occasional spasms and difficulty of breathing. Subsequent isolated periods of work with this Nematoid have also shown me that it takes from one month to six weeks for its effects entirely to disappear. In the spring of this year I again worked daily with these animals for nearly a month, till the symptoms became so severe as absolutely to compel me to desist. A certain change had come over their influence upon me. I now suffered far less from the more local irritating effects, and much more from the severity of the asthma and spasmodic cough. There was a curious kind of periodicity, too, about the worst attacks; they generally occurred between five and six o'clock in the morning and so regularly was this the case that it was almost needless for me to look at my watch, on awaking, to ascertain the hour."

Goldschmidt (*Münch. med. Woch.*, 57, p. 1991, Sept. 20, 1910) has collected an extensive series of cases and recorded varying degrees of severity among them. In some a single experience resulted in a severe attack the effects of which lasted for months. The first symptoms are ocular and nasal and later these become in general asthmatic.

Linstow had the misfortune to get a drop of the poison into his eye whereupon a severe conjunctivitis supervened and lasted for a long period. In another case within 15 minutes after working on such specimens there had formed on the conjunctiva a number of small vesicles which, however, disappeared later.

Dorff (*Klin. Monatsbl. f. Augenheilk.*, 50, p. 670, 1912) made a careful study of ascario-conjunctivitis and carried out a series of experiments on various animals. He concludes that the cœlomic fluid of the worm contains materials which on introduction into the conjunctival sac of susceptible individuals produces active inflammatory phenomena that vary with the species of animal and also with the individual to such a degree that all stages are represented from complete immunity to the highest degree of susceptibility. The point of attack is probably in the wall of the blood vessels as the effect is suppressed by the introduction of adrenalin. The material falls into the series of plant and animal poisons which are definite vascular toxins.

and are characterized by the physiological specificity of their action in different individuals. Passing the material through a bacterial filter does not alter its activity, nor is the result influenced by the addition or removal of lime.

Trichinella spiralis, a common parasite of rat and hog, produces in man the disease known as trichinosis. The young trichinæ produced in large numbers and emptied into the lymphatics of the intestine directly from the pregnant female, are carried over the body by the circulation; in the muscles the larvæ bore out and enter the muscle fibers where they encyst. From this habit of invading muscle cells it is evident that they may attack the optic muscles and at least in case of a heavy infection are likely to affect the action of the eye. It has been shown that in the case of the hog the eye muscles are particularly heavily infected; I have not found any reference to this condition in the human host. It is possible also that the larvæ circulating in the blood may exert an unfavorable influence on the retina, as is the case with other Nematode larvæ; such an effect should be apparent on ophthalmoscopic examination during the progress of an attack or soon thereafter.

The eye symptoms which have been recorded in trichinosis include conjunctivitis, disturbance of accommodation, double vision, painful sensitiveness to light, pupillar expansion, and ecchymoses in the conjunctiva bulbi. The slight exophthalmos is evidently due to edema of orbital tissues and the pains accompanying eye movements as noted by some may be due to the swelling or to young trichinæ in the optic muscles. Friederich (*Dtsch. Arch. f. klin. Med.*, 9, p. 459, 1872) designates as collateral edema due to toxic materials in the circulation, the marked edema of the lids which seems to be present regularly in trichinosis. This symptom was absent only in 65 cases out of 250 in the famous Hedersleben epidemic. It appeared in the course of the second week of the disease and was accompanied by a chemosis of the conjunctiva. Whether this effect is due in whole or part to the presence of parasites in the vessels of the eyeball and in the optic muscles, or whether it is caused by general systematic conditions and hence should be considered as one of those indirect effects of parasitism which are to be discussed under the next subdivision of the subject, is not clear from the evidence at hand.

ANIMAL PARASITES AFFECTING THE EYE INDIRECTLY

There are several Nematodes parasitic in man that exert a marked influence on the organ of vision although they do not come in any way

or at any time directly in contact with it. These forms are best considered in a group by themselves and apart from the other Nematodes. The forms of which such an effect is described are first the hook-worms, *Ancylostoma* and *Necator,* belonging to the suborder of the Strongyloidea, or strongyles, and, second, the stomach and seat-worms, *Ascaris* and *Oxyuris,* belonging to the suborder of the Ascaroidea. Since the ophthalmologist does not have to do with these parasites directly a special description of their structure may be omitted here and attention directed briefly to the effects on the eye produced by their presence in the alimentary canal.

Two kinds of hook-worms are found as parasites of man and are abundant in many tropical and sub-tropical regions of the world. *Ancylostoma duodenale,* commonly designated the Old World or European hook-worm, was discovered and described in Europe about 70 years ago, though evidence at hand shows its ravages among different nations for at least four thousand years. *Necator americanus,* the hook-worm of the New World, was discovered in this country by C. W. Stiles in 1902. While this species has been designated the American hook-worm, there is strong ground for the view that it was introduced into this continent through the slave trade and is at home in equatorial Africa. It is all in all the tropical species, whereas *Ancylostoma duodenale* is sub-tropical in distribution. Some points on the structure, life history and habits of these worms have already been noted elsewhere in this work. No evidence has yet been furnished to demonstrate any difference in the effects produced by the two species and while Necator is altogether the most abundant on this continent the problem of hook-worm disease in its relation to eye troubles may be discussed without any effort to discriminate as to which species is concerned. According to the reports available the effects of Necator are more intense and long enduring than those of Ancylostoma.

The various symptoms of hook-worm disease are traceable clearly to the profound anemia which grips the host. The loss of blood from the intestinal wall through the numerous minute hemorrhages from the points attacked by the parasites is of importance in the production of this condition but is not regarded as adequate to explain the condition fully. Many authors, among whom should be mentioned prominently Ashford, King and Guiterrez, maintain that the ancylostoma anemia is produced secondarily through a toxin. The authors cited had opportunity to study in Porto Rico a very extensive series of cases under circumstances that were favorable for careful investigation. They emphasize the appearance of nervous and in-

testinal symptoms before the anemia is evident, the lack of correspondence between the severity of the anemia and of other symptoms, the simple presence of symptoms purely confined to intoxication anemias and force the conclusion that the ancylostoma anemia is unquestionably a toxemia.

Blurred vision, diplopia and night-blindness, in 5 to 25 per cent. of cases, with undue expansion of the pupil, are some of the features displayed on external inspection. Unilateral and bilateral nystagmus, amaurosis, restriction in visual field and other asthenopic symptoms are also listed by Ashford. Stiles emphasizes a peculiar appearance, denominated a fish-like stare as a frequent and valuable diagnostic symptom, and this accords well with the description given by others. He says "If the patient is directed to stare intently into the observer's eyes the pupils dilate, then the patient's eyes assume a dull, blank, almost fish-like or cadaveric stare." But some recent workers are unable to verify his observations in such a degree as would warrant them in accepting the condition for diagnosis. These visual disturbances are often noted where anemia has not distinctly set in and in part, at least, are seen in infections with other intestinal parasites. In Porto Rico among carefully observed cases over 70 per cent. showed evident ocular disturbances.

Examination with the ophthalmoscope reveals significant changes in the interior of the eye. Over fifty per cent. of all cases are marked by a very pallid fundus. Retinal arteries are reduced in caliber; both pulsating arteries and retinal hemorrhages are frequently seen. All these might be found in chlorosis or other anemia, and somewhat similar conditions are present in filariasis as herein noted (cf. *Filaria bancrofti*,), but the two can be differentiated. It was Fischer who in 1892 first reported retinal hemorrhages in ancylostomiasis and the observations have been abundantly confirmed by investigators since then. It is affirmed that characteristic retinal hemorrhages more numerous and earlier in the periphery than near the papilla or macula, and massed in groups of punctate form, are typical in hook-worm cases.

Cataract has also been attributed to hook-worm disease by many students of the malady. Calhoun (*Jour. Am. Med. Assn.*, 59, p. 1075, Sept. 21, 1912) reported in detail cases showing the onset of cataract due to anemia and toxemia in ancylostomiasis. He also listed a remarkable case of spontaneous bleeding from dilated veins in the retrotarsal fold of the conjunctiva in a girl of eleven which was associated with a heavy intestinal infection of hook-worms. A course of anthelmintic treatment, an iron tonic, and a weak epinephrin eye

wash as a local application brought the cessation of the hemorrhages. Calhoun is strongly inclined to view hook-worm disease as a definite cause of cataract and calls attention to the dependence of the lens upon surrounding fluids for its nourishment, the necessary influence of alterations in these fluids on the capsule and lens, the evidence that toxins do produce changes in the capsular epithelium and cloudiness in the lens, and the similar effects of other systemic diseases such as cholera and pellagra.

More recently, Jervey (*Jour. Amer. Med. Assn.*, 63, p. 151, July 11, 1914) has gone into the matter further on the basis of a study of a long series of cases which are tabulated to show the eye symptoms in each instance. The records of previous observers in this country and abroad are also collated to show what phenomena they have observed and attributed to ancylostomiasis. Jervey is of the opinion that any of these numerous symptoms and pathologic conditions may be expected in ordinary cases of anemia and sees in the retinal hemorrhages, which is the lesion most frequently noted and emphasized, as well as in their peripheral location which is significant to some authors, only a common feature of other anemias as well. I have mentioned in the discussion of filariasis the work done in Samoa by Leber with the ophthalmoscope and the frequent presence of retinal hemorrhage in that parasitic malady. It should be noted that Leber emphasizes the frequence of such phenomena there as elsewhere and yet he specifically discusses their peculiar features in filariasis and the possibility of making a differential diagnosis from hook-worm disease by the characteristic facies of the picture presented by the ophthalmoscope. Evidently Jervey's conclusions need further elaboration before they can be finally accepted.

With regard to the rôle of a hook-worm toxin in the formation of cataracts Jervey queries its probability since only five such cases have been reported in the southern United States where some 40 per cent. of the rural population are afflicted with hook-worm disease. He concludes therefore that this malady is only indirectly a causative factor in the many forms of optic lesion associated with it, and that, by virtue of the anemia and general systemic condition due to the hookworm attack. He is pronounced in favoring the view that no eye lesions are in any sense sufficiently distinctive or characteristic to be of diagnostic value.

Bietti (*Annali di Ottalmol.*, 36, p. 551) reported a case of amblyopia and central scotoma as a result of ancylostomiasis. The trouble with the optic nerve must be, he states, regarded as a toxemia in which circulatory disturbances had caused a sudden reduction in sharpness of

vision. After eliminating the cause of the disease only a very moderate improvement in power of vision was observed since the fibres of the optic nerve had been damaged equally by the ischemia and by the toxins.

Inouye (*Opthal. Klinik*, 6, p. 99, 1902) described in detail a case of retrobulbar neuritis in a Japanese peasant. The sharpness of vision was materially improved for a few days by administration of potassium iodide but then remained unaltered despite continuance of the treatment until the presence of the parasite had been demonstrated by fecal examination and the worms removed by thymol treatment. Three days after the first thymol administration an improvement was noted and by the tenth day the patient's sight had become normal.

The etiologic connection between the eyes and the intestinal parasites remains still a matter of controversy, as appears from this discussion. It may be due to a pronounced anemic condition of the patient resulting from loss of blood and digestive disturbances, or to the reflex circulatory troubles traceable to constant irritation of the intestinal wall by the parasites, or finally to the influence of a toxic material produced by the worms and absorbed by the alimentary canal. At present the weight of evidence seems to favor the view that these effects are due to a toxin.

The larvæ of hook-worms and of some other Nematodes circulate in the blood of man during one stage of their life history. While not usually reaching the eye one must keep in mind the chance that in some cases such larvæ may reach retinal vessels and affect directly the structure and functional power of that layer.

Oxyuris vermicularis. In cases of infection with the seat-worm or pin-worm many symptoms of eye disturbance have been noted. These concern vision mostly, though paralysis of eye muscles has been traced to this parasite, and also to the hair-worm, *Trichuris trichiura.* The phenomena are not well understood and doubtless also their relation to the presumed cause, the intestinal parasite, is too distant to suggest itself readily so that it may be overlooked entirely in many cases. An exact investigation of these conditions with complete data on optic conditions would be a valuable contribution to knowledge.

Indirect influences on the eye are exerted by tape-worms in the alimentary canal as well as by Nematodes. The symptoms reported by various observers are general and more or less similar in reports concerning different species. They are also to some extent identical with the symptoms and pathological findings in cases of hook-worm disease just discussed. Thus it is recorded that in persons afflicted with the pork tape-worm, *Tænia solium,* loss of pupillary reaction and other

symptoms of tabes dorsalis have been observed. These features are purely temporary, disappearing promptly in the specific case with removal of the parasite.

Dibothriocephalus latus, the broad or fish tape-worm of man, is associated with an extreme anemia which is progressive and fatal in cases, but differs from true pernicious anemia in that it is cured completely, and in very brief time, by the removal of the worm. A mass of evidence both observational and experimental supports the view that this anemia is due to a toxin absorbed from the intestine and affecting the composition of the blood and blood cells, as perhaps also the hematopoietic organs. It is not surprising to learn from records of such cases that so profound an anemia affects the optic organs. Functional disturbances are seen, the power of vision being greatly reduced; the pallor of the fundus, the vanishing limits of the papilla and even retinal hemorrhages all mark the anemic condition as severe. Special data concerning these phenomena which may apply equally to other morbid conditions in the body, are not available.

HIRUDINEA

The class of leeches holds for the most part predacious, free-living animals some of which have assumed a temporary or occasional ectoparasitic habit that leads in a few extreme cases to permanency of location on a given host and constancy of the method of subsistence by sucking blood. Leeches are elongate, somewhat flattened, annulated forms which are closely related to the earthworms. They were formerly employed uniformly for blood-letting, a practice which not only survives but has been on the increase in very recent years. They are always accidental parasites of man, occasionally brought by chance onto the external surface of the body, more frequently placed there by design for medical purposes. Cases in which they have acquired relations to the optic organ are among the greatest of rarities; some cases result, however, from each of the conditions outlined in the previous sentence by which the leech gains contact with the human organism.

The medicinal leech, *Hirudo medicinalis* L., is a native of Europe though now exterminated nearly everywhere and maintained only under domestication in leech farms. It was known to the ancients, but did not come into general use for phlebotomy until the XIX century. It has been known to do damage to the eye by shifting to that organ from the point where it was put. A leech had been placed in one instance on the right temple of a girl aged 5 years with a view to relieving a severe headache. It made its way into the eye and

became very painful so that its removal was effected. Examination showed on the lower half of the cornea some two millimeters from the margin of the limbus the characteristic marks of a leech bite. The wound was large with margins and surrounding tissues swollen, cloudy and gray in color. The anterior chamber was filled with blood and the lower half of the sac, including the cornea, was infiltrated with it. A complete hemorrhagic detachment of the retina was also found and this was an adequate explanation of the entire lack of sensitiveness to light. The intra- and extra-ocular bleeding was apparently due to the strong suction to which the organ had been subjected. The blood disappeared very slowly.

A case is also on record in which the changes in the eye were apparently due to the introduction of toxic materials, or possibly of the anticoagulin known as hirudin which is produced in relatively large quantities in prominent acinous salivary or esophageal glands which the leech possesses. Lebrun (*Ann. d'oculist.*, p. 136, Oct. 1870) saw a man 39 years old who because of an inflammation of the right eye had put on a leech; the worm bit into the bulbus oculi as shown by the characteristic triradiate wound on the lower outer margin of the cornea. The pupil was dislocated as after an iridodesis and an iritis was present. A noticeable hypopyon existed, filling the deeper part of the anterior chamber., The bulb appeared somewhat flabby but the lens was normal. A chronic inflammatory process set in, the pupil closed and the bulb appeared to be shrinking away. Two months later the left eye became very painful. Ciliary congestion was noticeable though the cornea and iris both appeared normal. At this stage the right bulbus oculi was enucleated whereupon the changes in the left eye ceased at once and the organ became normal.

Limnatis nilotica Sav. is a smaller leech native to the circum-mediterranean region, and especially on the northern coasts of Africa abundant enough to constitute a veritable pest. Especially the young forms are swallowed by accident in drinking and remain for a long time fixed in pharynx, esophagus, trachea, or nasal cavities with serious results to the host. Either by migration from some of the regions noted or by accidental transfer by the hands specimens of this leech have been carried to the conjunctiva where even a single specimen evokes serious symptoms if not removed immediately. This can occur only with small, young specimens as the adult is 8 to 10 cm. long, i. e., about the same size as the medicinal leech.

In the East there are land leeches, much smaller than the medicinal species. These are extraordinarily abundant in most parts of Japan, Ceylon, the East Indies, and the Philippine Islands and in myriads

attack travelers in these regions. *Hamadipsa zeylanica,* or *H. japonica,* often called the Japan leech, is one of these forms which is frequently mentioned. The adult is only 10 to 20 mm. long and while they bite gently the wound is deep so that it is hard to see why a single specimen in the eye appears to produce only minor disturbances. In one case a peasant is reported to have told his fellow that a black object was to be seen in his eye. The man had suffered from chronic trachoma and had also complained of a twitching that often appeared and that he had endeavored to eliminate by rubbing the eye with his finger. At such times he noticed subsequently more or less bleeding from the organ. In the left eye was found near the external angle of the lid a black object which moved about and twisted like a worm; when stimulated it at once withdrew beneath the upper lid where it had sucked or bitten itself into the upper transitional fold. It was washed out of its hiding place by the use of salt solution and found to measure 27 mm. in length. While the length of its stay could not be clearly determined from the data available it had not done any serious harm to the eye.

Kiwahara (*Centralbl. f. prakt. Augenheilk.,* p. 262, 1903) relates the case of a girl who complained that the eye was somewhat painful, sensitive to light and watered a great deal. Examination showed the presence of a leech 2 mm. long. It was removed. The cornea was found to be strongly inflamed and showed scars at various points.

ARTHROPODA

The arthropods are readily recognized by the bilaterally symmetrical, segmented body with jointed paired appendages and firm resistant cuticular exo-skeleton, or shell. In some cases the appendages are greatly reduced or even almost entirely wanting. The body is commonly subdivided into groups of segments, or regions, that are conspicuously separated from adjacent regions, giving to the organism a characteristic appearance that is well known and readily recognized. There will be consequently little trouble in identifying such forms in a general way whenever they are involved in any eye troubles, due caution being taken of course to examine the suspected objects under a lens of sufficient magnifying power to demonstrate the true character of a minute structure.

Systematists recognize in the group of Arthropods five classes, the Crustaceans, Protracheates, Arachnoids, Myriapods and Insects, which with the exception of the second are among the most widely distributed and commonly known of free-living animals. Very few of them are under any circumstances true internal parasites and fewer still affect

in this way the human host, while none of them demand consideration here as forms which in that rôle affect the eye. Many of them, however, are biting, stinging, and blood-sucking external parasites, or burrowing forms that live in the skin or near the surface of the body of their hosts. Among these are the common, well known ectoparasites of man. To their significance as direct causes of human disease has been added, by the rapidly accumulating evidence of recent years, a more sinister rôle as inoculators of microscopic disease germs; it has been demonstrated that in many instances they are essential factors in the transmission of such diseases and hence of first importance in the consideration of the pathology, prognosis, and prevention of these maladies. The relations of such external parasites to ocular diseases are indirect and general in character for the most part. They have been noted already in this article under the sub-heading of the Protozoa, the causal organisms, and need not be discussed further in this place.

Among the Arthropods are some species that under certain circumstances make direct attacks upon the bulbus oculi or associated structures and these demand further definite consideration here. They are all ectoparasites which by force of conditions have been introduced into the eye and have found its tissues a favorable point of attack. The biting or sucking mouth parts and the spinous or uncinate appendages produce rapid and often serious effects on the soft ocular tissues and in cases where prompt action for relief has not been taken, the results have been of the most serious and destructive character. Fortunately such instances are rare, nevertheless emphasis should be laid upon the need for the immediate removal of these organisims because of their marked power to produce radical injuries.

The Crustaceans are normally aquatic forms and have little opportunity to gain access to the eye save in the case of swimmers and I know of no instance in which indulgence in this sport has resulted in introducing an aquatic organism into the eye. One must, however, recognize the evident chance that sometime such an event may take place. This is all the more probable since certain groups of crustacea, which are sometimes called fish-lice and live as external parasites on the skin of fishes, possess a free-living young stage; during this period they migrate actively through the water in search of a new host and might well settle by chance on the conjunctiva of a bather.

Evidence is furnished by a few interesting cases that the fish-lice find the mucous membrane of the eye a favorable site for attachment since such parasites have been removed from this very position. The cases on record concern fishermen or fish handlers as hosts and parasi-

tic copepods belonging to the Caligidæ as invaders. Thus R. Bettin (*London Lancet*, p. 1002, April 7, 1900) describes the discovery in the left eye of a fisherman of a cyst-like body, approximately 2 mm. in diameter, which was located near the upper corneal margin. An attempt to open the supposed cyst evoked activity and it was lifted out leaving only a slight roughness on the corneal surface. The form, which was provisionally identified as *Caligus curtus*, undoubtedly was transferred to the human eye by accident from the surface of some fish that was handled. Such parasites are so common on the exterior of fish and on the gills that the transfer is readily explicable, especially when one considers the frequence with which workmen use the bare fingers to rub the eye or remove water thrown in it during the pursuit of their trade.

Such forms would find the location favorable and being relatively inactive as well as possessed of weak appendages, would probably not work great injury. Their removal also is a simple matter, through virtue of their power of adhering to moist surfaces it is evidently different from that of removing inanimate bodies and they are likely to resist successfully the methods employed by the non-professional helper. Mechanical stimulation with the tip of a fine forceps will cause the animal to lift the body sufficiently to enable the oculist to grasp it, when gentle traction will suffice for its complete removal. Too rapid or powerful traction would be likely to result in leaving a part of the fish-louse behind and perhaps also empty into the eye irritating materials from its body.

Among the Arachnoids mention need be made only briefly of spiders and mites. The local irritation evoked by spider's bite is somewhat more pronounced when it occurs on the eyelid than on most other parts of the body. There are many mites which normally live on lower animals or on plants but which are accidentally brought on to the human skin and evoke there a dermatitis varying in degree, or even more deep-seated troubles. Famous among these are grain mites, the red spider (*Leptus autummalis*) of the southern and central United States, the Japanese Kedani mite, etc. Rarely such species are reported on the eyelids, where their attacks are more noticeable than elsewhere but not essentially different. Such cases call for no especial consideration here.

Numerous isolated cases of the work of the red spider have been observed in the United States. Of a similar character, though not so positively established, is the periodic troubles among workmen in the bulb nurseries of Haarlem during August and September. W. Zeper (*Klin. Monatsbl. f. Augenheilk.*, p. 480, 1899) describes a persistent

irritation of the skin and eyes among the workers cleaning and sorting bulbs. In the refuse can be found many free-living mites which apparently propagate themselves in this environment; they are allied to the grain and harvest mites mentioned above. While no one has yet succeeded in finding either larvæ or adults in the skin or conjunctival sac, the author was inclined to assign an etiologic rôle to the mites because of the marked correspondence of the symptoms and results to those in demonstrated cases of acarid dermatitis.

In other hosts than man mites often produce a catarrhal affection, as is the case in dogs, for instance. Furthermore, in Porto Rico are found mites that produce ulcers on the eyelids of cattle; these are said to call forth by their bites on the human eyelid a powerful twitching reaction. This favors the view that the bite of the mite is accompanied by the injection of some irritating or poisonous secretion. One finds at the point of the attack an accumulation of pus and also often a serous exudate.

Much the same may be said of the poultry mite, *Dermanyssus gallinæ*, which lives in crevices of the hen houses during the day and emerges at night to suck the blood of the fowls. In many cases it passes from birds onto other hosts, even occasionally to the human host, chiefly poultry handlers. It produces a papular dermatitis of an eczematous character, most frequently on the forearm or the back of the hand.

Fischer discusses a case of especial interest to us; a woman complained of pain in the eye and showed a small body firmly implanted on the cornea, which Fischer extracted with a fragment of the cornea and described as a ''hen flea.'' It had doubtless been conveyed directly to the eye by the flapping of the wing of a bird taken in the hands. The description of Fischer indicates that in all probability the ''flea'' was nothing more than the well known *Dermanyssus gallinæ*, one of the Gamasid mites. The case is explained by others as due to the hen louse, *Lipeurus variabilis.*

The ticks (Ixodidæ) are very large mites that regularly suck blood. They possess a prominent proboscis covered with retrose scales or spines so that once buried in the tissue of the host this organ can not easily be extracted. Only a small part of the numerous species display any tendency to assail the human host in search of food. Certain forms, like the common wood ticks which are normally parasitic on dogs and other large mammals, are brushed from foliage by men passing along and seek to penetrate the skin of this chance host. The point of attack may often be the eyelid where the parasite soon makes its presence painfully apparent. When the tick is discovered the

proboscis has been imbedded so deeply in the skin that the attempt to remove it forcibly usually results in tearing off the body; the portion left in the wound causes a most painful and sometimes serious inflammation. This accident may be prevented by painting the body of the tick with vaseline or by covering it with a small drop of oil whereupon the tick releases its hold and can be removed entire and the untoward sequelæ prevented. Some of these ticks transmit to other hosts the organisms that produce serious diseases, e. g., the Texas fever organism (Babesia) introduced into cattle by the cattle tick; but no such effects are known to be produced in the human host.

Among the itch mites (Sarcoptidæ) the common species (*Sarcoptes scabiei*) which infests man has been known to go onto the eye and cause trouble. A case reported by Saemisch (*Klin. Monatsbl. f. Augenheilk.*, p. 449, 1898) concerned a 19 year old peasant lad who had for two months experienced trouble in the eye. Examination revealed a cauliflower-shaped keratitis which was attached to a group of small vessels. It was gray, stringy mass in which lay a female itch mite with 8 eggs nearby, in various stages of development. The case was striking in that otherwise the body of the patient showed no trace of scabies.

Minute, elongate, almost worm-like forms with segmented abdominal region and with short stumpy feet belong to the follicle mites (Demodicidæ).

Demodex folliculorum, the human follicle mite, of which numerous poorly known varieties infest other hosts, occurs in the follicle glands of the eyelashes, or in the Meibomian glands. This mite is found in 50 to 60 per cent. of all persons examined (European statistics) regardless of their condition of life, hence some authors regard the presence of the parasite as purely accidental. None the less, Dubreuilh considers it necessary to record carefully their occurrence even though they may be found in healthy follicles since their abundant presence may determine the diseased condition.

Some writers hold that the hair follicle mite has no connection either with the formation of comedones or with sebaceous gland disease. Others just as distinctly maintain that it is the cause of certain morbid conditions of the eyelids. A third group considers it without significance when present in moderate numbers but capable of producing pathological conditions when large numbers are present. The evidence is confusing and to some extent contradictory. Mulder (*Nederl. Tydschs. f. Geneesk.*, p. 803, 1899) from the record of a series of 95 post mortems concludes that 86 per cent. of the population carry the parasites abundantly in the healthy eyelids and show no evidence of eye trouble during life. On the other hand Graefe-Saemisch cites

numerous earlier authorities to prove that when the mites infest the Meibomian glands, an inflammation is produced in the epithelium and in the peripheral subcutaneous tissues, manifesting itself in the formation of small cysts. The eye waters and twitches, the eyelid is swollen and its inner surface is inflamed. Even more positive data are found

Fig. 15. *Pediculus humanus.* Dorsal view, × 14. After Braun.

in later authors that when the mites are present in large numbers one finds the cilia falling out, the eyes weak and watery, the lids swollen and other evidences of irritation manifest. It has also been maintained that in cases of trachoma the mites are especially abundant and add to the difficulties due to that disease.

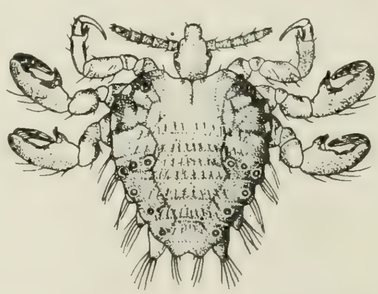


Fig. 16. *Phthirius pubis.* Dorsal view of female × 20. After Castallani and Chalmers.

The true Insects are recognizable by the division of the adult body into three regions, the non-segmented head, the thorax, with its three pairs of appendages and regularly two pairs of wings, and the segmented abdomen. Among the large number of forms included in the group Insecta only a few are of interest in this connection. Their relations to the eye are all incidental if not accidental in that this

organ is not selected for attack by virtue of any predilection for the location or limitation of activity to the tissues of this region.

The lice (Siphunculata) include true ecto-parasites of man of a stationary or permanent character. They are small, flattened, and wingless, with piercing and sucking mouth parts, and short, powerful, grasping legs.

Three species of lice, grouped in two genera, infest the human host and may be found in connection with eye troubles. These species are *Pediculus humanus* (wrongly called *P. capitis*) the head louse, *Pediculus corporis* (=*P. vestimenti*), the clothes louse, and *Phthirius pubis*, the pubic or crab louse. The necessity of distinguishing these types in

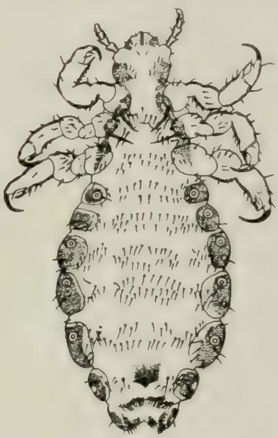


Fig. 17. *Pediculus corporis.* Ventral view. × 14. After Braun.

individual cases calls for some discussion of their structure and the features on which a differential diagnosis depends.

In the genus Pediculus (Figs. 15, 17) the abdomen is broader than the thorax, and is without any lateral appendages whatever. The thoracic appendages are approximately equal in length and in strength; the thumb-like projection from the penultimate joint is a slender spine of some length. In Phthirius (Fig. 16) the abdomen and thorax are of equal width so that the line between them is little marked. On the abdomen the first five segments are closely compressed and segments V to VIII inclusive carry lateral conical appendages with long bristles. The first thoracic appendage is much shorter and lighter than the others, and its claw also is longer and slenderer; the thumb-like process is short and heavy in comparison with that in Pediculus.

The two species (*Pediculus humanus* and *P. corporis*) are so much alike that many authors have regarded them as identical and records

of their occurrence are somewhat confused. It will be of service to present their measurements in tabular form for ready comparison: all measurements are given in millimeters.

DIMENSIONS OF MALE

	Length of Body	Head Length, Width	Length of Antennæ	Width of Thorax	Width of Abdomen
Head louse	2.46	0.39x0.36	0.29	0.62	0.84
Body louse	3.19	0.48x0.42	0.43	0.78	1.07

DIMENSIONS OF FEMALE

	Length of Body	Head Length, Width	Length of Antennæ	Width of Thorax	Width of Abdomen
Head louse	3.03	0.43x0.42	0.32	0.74	1.13
Body louse	4.13	0.57x0.47	0.40	0.87	1.59

The table shows clearly that the head louse is smaller than the body louse in all dimensions of both sexes. The figures will illustrate some slight but constant differences in form of the head, shape of particular joints and distribution of setæ as well as length and weight of the latter. While the head louse varies in color somewhat after the hair color of the host, it is always darker than the body louse, which is colorless. The eggs of the head louse are smaller than those of the body louse (0.6:0.8 mm.) and are different in form and manner of attachment (see Fig. 18). From its usual abiding place in the hair of the head, *Pediculus humanus* is of much greater significance to the oculist.

Head lice have been often indicated as the cause of blepharitis and phlyctenular conjunctivitis, but opinions are divergent. Thus Jullien (*Ann. d'oculiste*, 106, p. 450) observed many cases in which lice were even abundant on the margin of the eyelids and nits were found on the eyelashes, but no eye troubles were present. On the other hand Herz, Gordon-Norrie (*Centralbl. prakt. Augenheilk.*, p. 296, 1895) and Font-Reaulx (*Arch. parasitol.*, 15, p. 385) have investigated numerous serious cases of inflammation of the type mentioned and found them susceptible of immediate cure once the head lice were eliminated. Norrie indeed observed that the troubles recurred as soon as the lice appeared again after a cure. In consequence of such observations these and other authors support insistently the view that the mites are the primary cause of the trouble.

The pubic louse, or crab louse (*Phthirius pubis*), has been found often on the heavy hairs of the eyebrows and eyelashes, especially among children to whom at least three cases out of four belong. Even the youngest may be infested and Heisler (*Arch. Dermat. u. Syph.*, 24, p. 590) reports a boy 14 months old whose eyelashes and eyebrows, as well as other parts, were richly infested with these lice,

Dallas (*Rev. med. e. pharm.*, 1877) observed in a child of 3 years constant rubbing of the lids and an active twitching in the right eye. The conjunctiva was considerably reddened and two small granular spots on the margin of the upper lid revealed themselves as lice. It was shown that the infestation had been transmitted by the nurse.

On the other hand the presence of such pests about the eye seems to be of no significance in other cases. Thus Harkness (*Ophth. Hosp. Rept.*, 2, p. 125, 1860) reported a woman with chronic ophthalmia of the left eye. Minute brown elevations ½ mm. long covered the right upper eyelid. Examination showed them to be eggs of the crab louse, and the lice themselves were found between the eyelashes. These conditions did not seem to disturb the patient. In many instances, how-

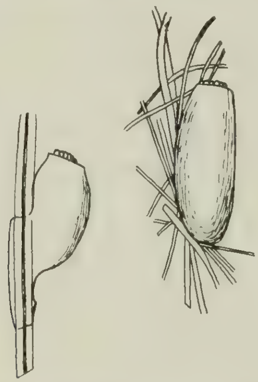


Fig. 18. Eggs of *Pediculus humanus* (at left) attached to hair, × 50, and *P. corporis* (at right) attached to threads of clothing, × 40. After Cholodkovsky.

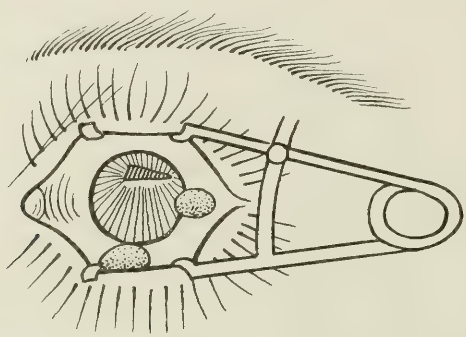
ever, not only inflammation but also excessive tear production, as well as subjective symptoms of irritation, are associated with the occurrence of the lice. The lice are ordinarily at the root of the eyelashes and the patient experiences a burning sensation associated with tear production.

According to Chisholm (*Am. Jour. Ophthalm.*, p. 161, 1892) red or gray mercury salve should be rubbed into the skin with a short, stiff-haired bristle brush. Washing with sublimate solution, or painting with tincture of iodine or carbol solution, 5 per cent. aqueous to 10 per cent. alcoholic, may also be used. The frequent practice of cutting off the eyelashes does not appear to be necessary.

All of the biting insects that attack man may at times visit the eye. The various bed-bugs are known to have given rise by their bites to inflammation and swelling of the lids. The famous "kissing bug" under which name are included several distinct species of insect, has

been reported in the press as having settled on the eyelids and bitten them. Some of these species evidently produce a glandular secretion that is poisonous when injected into the human system; but in other cases the results are equally clearly due to the inoculation of pathogenic germs, as the local application of mercuric chloride resulted favorably. The bites of mosquitos, midges, etc., are often very painful when the lids constitute the point of attack.

The sand flea, chigo, or true chigger (*Sarcopsylla penetrans*) is a native of the western continent though transferred by the slave trade to Africa and now abundant there. The impregnated female bores into the skin, usually of the foot, and the rapid accumulation of innumerable eggs enlarges the anterior zone of the abdomen to the size of a pea, holding the insect firmly in place in the skin. Mense relates that they



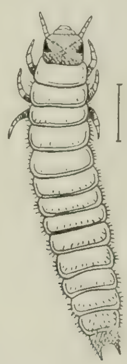
External appearance of eye with larva of coleopter in cyst. After Houlbert.

decorate the margin of the eyelids of parrots like a wreath. Chance permits them at times to bore into the human eyelid where the flea produces later a running sore in the center of which one can faintly distinguish the body of the insect. The removal of the flea is easily accomplished by a single operation.

The stinging insects (Hymenoptera) introduce into the wound a glandular secretion that is highly irritating and serves to explain fully the extreme reaction that follows the attack of such forms as the bee or wasp. Experimental evidence has shown that the poison produces a marked reaction on the uninjured conjunctiva of a rabbit eye, and when introduced beneath the surface of the skin gives rise to edema and hyperemia with local necrosis and infiltration of leucocytes. Persons familiar with bees believe that when enraged they endeavor to reach the eye of the individual attacked. Certainly the effects of a sting on the eyelid are serious and lasting. The prompt removal of the ovipositor, usually broken off in the wound may reduce the trouble by preventing the diffusion of all the poison in the sac.

In considering relations between beetles (Coleoptera) and the human eye one would naturally think of small flying types that occasionally dash in and by the discharge of an acrid secretion irritate the organ. This effect is exercised by different species in varying degree. Most painful of all are the results of contact with one of the blister beetles (Meloidæ) which possess in the body fluids, and especially in the reproductive organs, a peculiar volatile material known as cantharidin. While the amount discharged from a given insect may be very small, the effect may be painful and indeed serious. There are many of these cryptotoxic insects producing somewhat similar effects; the presence of cantharidin has not been demonstrated for many of them.

In at least one case a coleopterous larva has been taken from the human eye. The details of this very unique case are told by Houlbert



Larva of Necrobia from eye shown on p. 9338. After Houlbert.

(*Arch. parasitol.*, p. 551, 1910). In a girl of 14 years the left eye had on the surface of the sclera a small tumor the size of a small pea (see p. 9338). The mass was hard and disturbed the patient since it interfered with movements of the lid and irritated her even though it was not painful. A second tumor in the same eye was below and hidden ordinarily by the lower lid. This second body was larger (1.5 mm. long) soft and slightly yellow. This cyst was the seat of frequent itching and at times moved in the eye. Within the last 15 days it had remained quiet. An operation showed that the conjunctiva was slightly elevated and in the pocket thus formed was a little reddish larva, 8 mm. long (see Fig.). Immobile on the moment of its excision, the larva at once set about moving very actively. It was a beetle larva of the genus Necrobia which in this stage inhabits decomposing flesh. By chance the maid had handled waste containing young larvæ or eggs just ready to hatch and had conveyed one to her eye. The author

remarks on the chance that in superficial examination larvæ of Diptera or of other insects such as this one, especially if slightly mutilated in an operation, might readily be confused with the bladderworm stage of Tænia. Such confusion would serve to account in part for the frequent records of cysticercus in the eye.

One should consider here also the effects produced by the lodgment in the human eye of hairs of certain caterpillars or moths which cause a nodular conjunctivitis designated often as pseudo-tubercular because of a superficial likeness to tuberculosis of the conjunctiva.

de Schweinitz and Shumway (*Univ. Penn. Med. Bull.*, p. 270, Nov. 1904) reported in detail an interesting case of this ophthalmia nodosa in a child of 15 years. One eye was badly inflamed because of some

Fig. 19. Conjunctivitis Nodosa, with Histological Examination. By de Schweinitz and Shumway.

foreign substance present and an examination showed nodular elevations of the conjunctiva on the lower and inner surface of the bulb, together with congestion of the surface blood vessels in this region. The mass of nodules was removed and when sectioned showed in the outer portion of each nodule concentric layers of spindle cells and round cells. Each nodule also contained a number of giant cells. In the center of some nodules was a fragment of a hair surrounded by epitheloid cells that had much intercellular substance (see Fig. 1). On the outside the tissue was condensed into a capsule. The condition was traced to the fact that the child had played with caterpillars, and a particular species of moth, *Spilosoma virginica*, was held responsible although its culpability was not positively established.

Other forms might easily give rise to similar troubles and especially the brown-tailed moth, *Euproctis chrysorrhea,* which gives rise to a most serious dermatitis. Tyzzer has shown that in this case the short, barbed hairs contain a poison which effects rapid and marked changes in the erythrocytes. It may well be that the changes already described in ophthalmia nodosa are brought about by the influence of some poisonous secretion emitted from the hairs that reach the eye.

Among the *Diptera** or flies, many species especially in the tropics are occasional assailants of the eye, bringing, like mosquitoes, actual poison to the tissues, or inoculating foreign disease-producing germs which are in or on the proboscis, or again like many Tabanids biting severely and so poisoning the wound that painful twitching with thickenings and nodules remain for months. Further the larvæ or maggots may be encountered at times in the human tissues and so also in the eye. The latter cases deserve more extended consideration.

The disease caused by the worm-like maggots of the fly is generally designated *myiasis, myasis,* or *myiosis.* In general this complaint is rare in colder regions and most common in tropical or subtropical territory. It is also rarer in old, well-settled regions and more common in wild and unsettled countries. Thus it is very rare in western Europe but not infrequent in Russia and more often recorded in Italy than north of the Alps. Only certain species of fly are responsible for the trouble, and for the most part they are characteristic of given regions. These species and their work will be discussed in greater detail later on in this section. Betti and others refer to the prevalence of "mal di ojo" on the west coast of Mexico, Central and South America as reported by Eisen. This author described in the *American Journal of Ophthalmology* (11 p. 111-114, April 1894) a disease of the eye apparently transmitted by a fly but itself due to a small worm which he called a filaria. The data are too specific to permit one to interpret his record as erroneous or to assign the cause to fly larvæ in the eye as some have done.

Undoubtedly other species than those recorded here may at times attack the eye or adjacent parts as they do in fact other regions of the human body. The list of possible invaders is a long one and the determination of the individual species from the larval forms found in man not an easy task. Fortunately the eye is rarely subject to such invasion.

All such cases are designated *myiasis externa,* s. *dermatosa,* s. *cutanea.* Treatment is first of all a question of the removal of the

* A brief outline of the classification of this large and very complicated group may be found under the heading **Diptera**, p. 4016, Vol. VI of this work.

larvæ and the latter should never be thrown away or destroyed but kept for future more careful examination. Preparatory to this, they should be preserved in formol or alcohol as this will facilitate the identification of the species and the subsequent determination of the mode of invasion.

In order to determine most readily and positively the species of fly to which the larva belongs, the latter must be kept and bred to maturity; as this is difficult or impossible the larvæ may be carefully preserved and later subjected to precise study. Unless the maggots are "ripe" and ready to pupate attempts to breed the adult are without results.

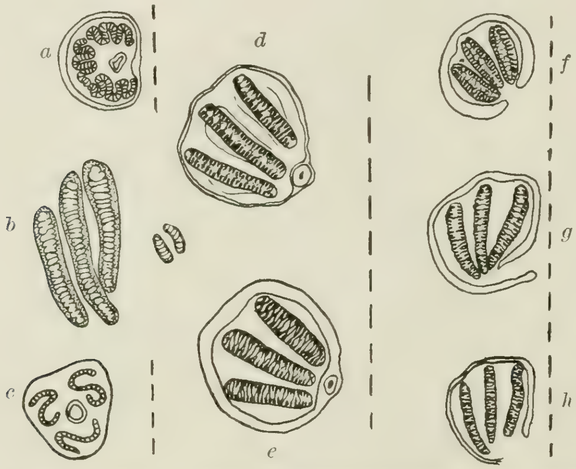


Fig. 20. Posterior stigmal plates of various dipterous larvæ. The heavy dotted line shows the location of the median plane. *a, Musca domestica,* × 40; *b, Dermatobia hominis,* × 80; *c, Stomoxys calcitrans; d, Lucilia cæsar;* × 40; *e, Calliphora vomitoria,* × 32; *f, Chrysomyia macellaria,* × 40; *g, h,* Sarcophaga, species unknown, × 40. *a, d, e,* after MacGregor; c, f, g, h, after Riley and Johannsen; *b,* after Ward.

In determining the species of insect larvæ involved in any case it is of first importance to employ good diagnostic characters. Preeminent among such stand the posterior stigmata. The stigmal plates stand as two small yellow-brown dots one on each side of the median line at the posterior end of the larva. To secure good preparations MacGregor (*Parasitology*, 7, p. 176, 1914) recommends that the larva be hardened in alcohol and about 0.75 mm. of the posterior tip cut off. This piece is then boiled in 10 per cent. KOH until all tissue is removed. Properly mounted such a piece shows clearly the stigmata. The form of these organs is indicated in the accompanying figure for some of the more common species described in this text later on (Fig. 19).

The dipterous larvæ reported in some cases are clearly beyond determination primarily because of failure either to breed the adult from the specimens obtained or to preserve specimens carefully for precise examination. This is true of many reports concerning the presence of such larvæ in the eye.

Fly larvæ if deposited on the surface of the eye anywhere settle commonly in the conjunctival sac and produce serious changes only in relatively few cases. Certain kinds may be found also in the anterior chamber where their presence can be readily explained since such larvæ are provided with sharp hooks and normally burrow into the skin, producing typical sores ("boils" or warbles). By penetrating similarly the conjunctiva they reach the anterior chamber. One may thus readily distinguish two types of ophthalmomyiasis according to the habits of the fly larvæ. In the one case the maggots are not accustomed to burrow into tissues or are unable to penetrate the layers of the eye. They remain in consequence on the surface and the effects of their presence, though painful, are transient and complete recovery follows rapidly upon their removal. In the other case the larvæ are naturally destructive to living tissues and begin at once on introduction into the eye to burrow into its substance. Unless the removal of the invaders is accomplished with great promptness in such instances the damage is considerable and irreparable. The flies which display these different habits belong to different families and hence some authors speak for instance of an *ophthalmomyiasis œstrosa,* if the larva belong to some type of the Oestridæ.

Isolated instances of ocular parasitism are charged against species in several different families or groups of flies. Such cases are recorded for the Tachinidæ and Syrphidæ, but the majority of records concern members of the Oestridæ and Sarcophagidæ. The single cases are taken up first and later the families in which such parasitism is more frequent.

In one case in Italy reported by Baquis (*Ann. di ottalmol.,* 24, p. 329, 1895) a laborer was struck in the right eye by a small insect he thought resembled a butterfly. Shortly thereafter he experienced pain and itching and the symptoms became continually severer. Investigation about nine hours after the occurrence showed the lids badly swollen, the conjunctiva blood-shot and inflammatory catarrhal conditions. In the conjunctival sac were small, white, wormlike bodies. After dropping cocaine into the eye some 40 were taken out without difficulty. In three days the eye was again normal. The larvæ could not be determined as to genus or species but undoubtedly belonged in the family of the Tachinidæ. They have been wrongly ascribed to the

genus Gastrophilus by some reviewers and the case is erroneously indexed under that name.

The Syrphidæ, or flower flies, include one form Eristalis, in which the larvæ possess a long, anal breathing tube which gives them a characteristic appearance deserving the name "rat-tailed" that is popularly applied to them. Reis has reported such a larva in a case of ophthalmomyiasis with some care. Among the patients being examined for suspected trachoma was one, a man of 43, in whom the left conjunctival sac manifested slight catarrhal conditions and a dense secretion. After removal and closer examination, the supposed secretion revealed itself as a larva of one of the Syrphidæ probably *Eristalis tenax.*

Such larvæ live normally in dirty water, in stagnant pools, in privies, etc., and are very resistant. Probably the egg was laid in the conjunctival sac, and later the larvæ emerged there. It is, of course, possible that a very young larva in water used for washing was rubbed into the eye and took refuge beneath the lid. When found it lay so that the body was deeply concealed in the corneal sac whereas the end of the breathing tube projected near the caruncula lachrimalis.

The bot-flies or warble-flies (Oestridæ) are all parasitic during the larval stage; and the larvæ, known as "bots" often live in the skin or in the cavities of the head of man as well as other warm-blooded hosts. Usually a given species is confined to a single host but also may under circumstances attack man. They are warm weather insects and are active at midday in the sun, disappearing with clouds or rain. Some species are intestinal in larval habitat while others infest the skin, and a third type the mucous membranes of nose and throat. The latter are the most likely of all to go over to the conjunctiva when conditions favor the attack but the cuticolous species may infest the lids.

In the cutaneous œstrids eggs are deposited on the surface of the skin and the larvæ burrow into it as soon as they are hatched. Sometimes they carry out long migrations to attain an ultimate point for development and here they form swellings like boils or ulcers, the characteristic warbles common in domestic animals. Such a tumefaction bears at its summit a minute pore by which the larva secures air for respiratory purposes. These forms are readily recognized in a general way by the conditions just noted; the larvæ are also easily distinguished on exact comparison, though many accounts are confused because they lack specific items. The common cattle warble flies have all been reported from the human host. Some of these records establish their culpability as ocular parasites.

The larva of *Hypoderma lineata,* the common ox warble, migrates

through subcutaneous tissues long distances, always, however, upwards and ultimately makes its exit through an opening in a tumor in the upper regions of the body, i. e., on the head, neck, or shoulder. While very rare it does occur in man in this country as is shown by an interesting case found in *Insect Life* (2, p. 238; 4, p. 310). A bot was taken from the cheek near the eye of a child at Kane, Pa.; Dr. Freeman first saw it near the ear; six days later a red line of inflammation went to the eyelid and down the cheek. The mother stated the eye had been closed by the swelling for 24 hours. It was removed by lancing and the trouble disappeared. The bot had traveled from the elbow to the eye in a period of 5 months.

In England Menzies removed the bot of *H. bovis,* the larger warble fly, from the upper eyelid; it was nearly mature. Before removal it had produced a conspicuous swelling and had caused great pain; but the wound healed rapidly.

Both *Hypoderma lineata* and *Hypoderma bovis,* occur in various countries occasionally in the human lids and region of the eyebrows. There is still some doubt as to how the larva reaches the lid, but about it there develops a furunculous abscess or phlegmonous inflammation. Some cases from the European continent are carefully noted. A dipterous larva of genus Hypoderma, possibly *H. bovis,* was recently observed (Krautner, *Zeitsch. f. Augenheilk,* 4: 269, 1900), in the anterior chamber of a nine year old girl; shortly before she had been suddenly struck by the fly on the upper lid near the interior angle of the eye. It was conjectured that the egg laid in the eyelid grew to a larva, and this came either by its boring in or crawling through the cleft of the lids into the conjunctival sac and thence by piercing the cornea or otherwise into the anterior chamber. The conjunctiva was reddened, the cornea clear, the aqueous slightly cloudy. There was a little injection of the ciliary. On the posterior corneal surface one saw a band-shaped, motionless structure with 7 cross stripes. The pupil was narrow and reacted little to light; vision was greatly reduced. After about 3 weeks there was in the anterior chamber a hypopyon that was punctate. Later the 12 mm. long parasite was removed. The death of the girl followed, due to chloroform narcosis. There was present iritis, destruction of the membrane of Descemet, swelling and inflammatory infiltration of the membrana propria of the cornea.

Stahlberg reported a similar case in which a larva diagnosed as *Hypoderma bovis* was found in anterior chamber of the eye in a boy 5 years old. The eye was greatly inflamed and very painful. The larva was removed through an incision in the limbus and the trouble entirely disappeared. Ewetzy and von Kennel give an account of

other cases in which the larvæ had been in this location for some months. The appearance presented was that of irido-cyclitis. While the insect was not determined it was probably *Hypoderma bovis.* In Hess' case the larva was found in the pus in a case of chorio-retinitis with detached retina and removed. Recovery followed. The species was determined here as *H. bovis.*

Major R. H. Elliott reports that the larva of a species of Hypoderma occurs frequently in India in the eye of the horse. It carries on active movements in and out of both anterior and posterior chambers. A crude operation is performed to effect its removal.

In the tropical and sub-tropical regions of America the cuticolous œstrids are represented by the genus Dermatobia. In many regions it is a serious pest and while it attacks primarily mammals, both wild and domesticated, it has often been found parasitic in birds as well as man (Ward, *Mark Anniversary Volume,* art. 25, p. 483, 1903). Despite a variety of names employed by different authors, there seems to be only a single species properly called *Dermatobia hominis,* the name bestowed upon it by C. Linné, Jr. The three larval stages differ rather markedly in external appearance and this has led to the view that different species are involved. It is common enough in many parts of Central and South America to constitute a veritable pest to man as well as to the domestic animals of the territory. Recent investigations seem to show that the eggs are dispersed if not actually inoculated by various biting insects. A mosquito (*Psorophora lutzii*) and a tick (probably *Amblyomma cajennense*) have been assigned a part in this work. The acceptance of these views makes it easier to understand how the human host is infested and why the larvæ have been found in some of the locations on the body for which they are reported. This concerns especially some of the eye cases to be described next.

The maggots of *Dermatobia hominis* devolop at times in the human flesh, selecting a location at or near the surface of the skin. It is then not strange that in some cases such large larvæ have been found around the orbit in various tissues. Thus in Brazil Magalhães found the larvæ under the conjunctiva in one case and in a second within the lachrymal sac where the larva had given rise to an abscess and fistula.

Gradigeno's case (*Rev. gén. d' ophthal.,* 3, no. 5, 1894) was in an infant born in Brazil. In the center of a circumscribed swelling of the upper eyelid was a small pore from which at times a gray worm protruded itself. The case is unusual in that two larvæ, each 10-15 mm. long, were removed from the cavity. Lagleyze's case from Buenos Aires concerns a sailor in whom the larva was carried in the eyelid, but he mentions also a case reported by Moura in Rio de Janeiro where

the larva was in the lachrymal sac. This is spoken of as a larval œstrid but it was probably Dermatobia. Keyt (*Brit. Med. Jour.*, p. 316, Feb. 10, 1900) saw in British Honduras a ten-year-old native Indian boy who seemed to be suffering from epiphora of the right eye. He noted conjunctivitis, inflammation of the tear duct and lids, and an increase of ocular pressure in the prominent and extremely protruding eyeball. A small orifice was visible in the caruncle and from it protruded a minute opalescent body as large as the head of a pin. The operation for removal was successful though tedious because of the size and recurved dermal hooks of the larva. The illustrations given leave no doubt that the species present was *Dermatobia hominis.*

Perhaps the case described by Gann (*London Lancet,* Jan. 4, 1902; also *Jour. Trop. Med.*, 5, p. 114, April 1, 1902) concerns a Hypoderma as some have regarded it, though one is tempted to refer it to the genus Dermatobia which is common in tropical regions of the Western hemisphere. I place it here as the case came from Corozal, British Honduras, and seems characteristic otherwise of Dermatobia. The patient, a Spanish boy of 18, had been living sometime in the bush and noted during the last three months inconvenience and pain in the left eye as well as a sensation as of an object moving in the socket. The eye appeared more prominent than its opposite, the conjunctiva was congested and the entire inner canthus was enormously bulged forward. A circular orifice with a prominent rim was situated just inside the caruncula lachrymalis and from it a small knob was from time to time protruded.

In similar cases the negroes are accustomed to cover the pore with a plug of wet tobacco and after a day or two squeeze out the larva by force. As this was impossible here, the oculist injected a few minims of a strong solution of tobacco, covered the orifice with moist tobacco-leaf for a couple of hours and then, after an incision, drew out the larva with fine forceps. It was half grown. The wound healed and the sight of the eye was not impaired. The wonder is expressed by the author that the fly could deposit its egg in such a sensitive spot without the victim being conscious of the fact; it might easily be left there by a mosquito.

The cavicolous Oestridæ are flies which in the larval stage inhabit the nasal and frontal sinuses of large mammals, chiefly ruminants, the elephant, and the Equidæ. The larvæ drop out of the nose when full grown and pupate in the open. Nearly all the cases of such larvæ in man belong to the following species:

Oestrus ovis, or *Cephalomyia ovis*, the sheep-bot or warble-fly frequently lays its eggs in the nose, mouth, or eyes of man. Sergent

(*Ann. Inst. Pasteur*, p. 392, 1907) has studied cases in Algeria. They are unusually numerous in a valley of Kabylia where the complaint is common enough to receive a local name Thim'nis, which is also the name of the fly causing it. It affects chiefly the sheep herders. The fly infests the high pastures and never descends into the villages; while in flight it deposits its larvæ without alighting and in the nostrils or on the lips as well as in the eye. Those are especially likely to suffer who have eaten fresh cheese made from sheep or goat's milk. Dogs as well as men are attacked as they also eat the cheese.

At the time of attack a sharp pain is felt, vision is impossible, the conjunctiva becomes swollen at once and small, white active worms swarm on its surface. The natives remove these larvæ from the eye with the tip of a cloth. The trouble lasts 3 to 10 days and complete recovery always follows an attack. The disease is known only in certain mountainous regions where the sheep are less numerous than the human population.

The same authors later (*Bull. soc. path. exot.*, 6, p. 487, 1913) secured evidence of the existence of similar conditions in the central Sahara where among the mountains of Ahaggar at an elevation of 1,500 to 2,500 m. the people are persecuted in spring by these flies which deposit their eggs on the conjunctiva and also on the nasal mucosa. The predominance of ocular cases is a noteworthy feature of both these accounts.

A considerable series of European cases has been reported by Betti (*Ann. di ottalm.*, Pavia, 44, p. 337-352, 1915); four of these had come in his own practice within two years. The cases concerned patients of varying ages and of both sexes, and agreed in all important details. The individual affected was always in the open air and quiet but not asleep. An insect struck the eye with some force and in a moment flew away. Severe pains were experienced shortly. These were described by the patient as if some sharp body were scratching the cornea. The pains grew worse until within a few hours they became intolerable and aid was sought. Investigation showed that the eye affected was much inflamed, the lids red and swollen, the conjunctiva blotched with blood, and the tear flow excessive. In a fold of the conjunctiva small white worms were detected; they were long, slender and very active. In the first case 14 were removed and later others discovered in the nose and in the pharynx. In another 9 were taken out. In two cases some of these worms had been removed by the mother or sister using the tip of a bit of cloth; others remaining were extracted by the author. Careful examination showed that all the larvæ were identical and all belonged without question to the species

Oestrus ovis. A fifth case also from Italy, probably identical, was reported to the author and several more of a somewhat similar character were quoted from the literature. The case of Baquis, noted above, is like these in general features though the insect responsible in that instance belonged to a different family.

In all these cases it is noteworthy that the larvæ did not produce any permanent changes; their removal brought about a sudden and complete cessation of all disturbances and the eye was restored to a normal condition in short order. This is, of course, due to the fact that these larvæ manifest no tendency to burrow into living tissue and their presence in the eye is not accompanied by the destruction of any portion of that organ.

Another point is worthy of note. These flies are viviparous and actually remained in the eye but a moment as testified to by all the victims; living larvæ are deposited instantly and scatter at once so they were felt in the eye almost as soon as the adult insect flew away.

More serious consequences follow the attacks of another of the cavicolous Oestridæ. These cases are all reported from Russia and are well represented by the account of Riley and Johanssen (*Handb. Med. Entom.*, p. 115) who state that according to Portschinsky the Russian gad-fly (*Rhinœstrus nasalis*) which inhabits normally the naso-pharyngeal region of the horse, may also, and not infrequently does, attack man. In all recorded cases it deposits its larvæ in the eye only and this occurs when the victim is quiet though not during sleep. The fly strikes and deposits its larvæ while in flight. At once the patient experiences lancinating pains, growing in violence constantly. An intense conjunctivitis supervenes and unless the larvæ are extracted promptly the envelopes of the eye are consumed and the organ totally destroyed as the larvæ are exceedingly active.

The larvæ of the Sarcophagidæ or flesh-flies usually feed upon dead flesh though they have been found on living insects and sometimes also in man. In some of the latter cases they were feeding on diseased tissues, as in a malignant tumor, and in all instances they seem to have been attracted by the odor of the discharges. Thus in malignant inflammations of the eye these larvæ have been found under the eyelids and in Egypt, according to Pruner, smallpox pustules on the cornea are attacked and by the activity of the maggots are carried to perforation.

Not all cases are serious. Thus Kayser (*Klin. Monatsbl. f. Augenheilk.*, 43, p. 205, 1905) saw a child of 6 which had fly larvæ, probably Sarcophaga, in the conjunctival sac. The larvæ had induced an acute conjunctival catarrh which was only transient as the eye became fully

normal in three weeks after the larvæ were removed. The species of insect was not determined and it may not have belonged in this genus.

In most reported cases the results of the invasion of any species of Sarcophaga are more serious. Of the species concerned *S. carnaria* is most frequent.

The case of Cloquet was reported in 1823 as follows: A drunken man lay for some time sleeping in an open field and *S. carnaria* deposited its eggs among other places between his eyelids. From 15 to 20 maggots of this fly hatched out between the badly swollen and closely approximated lids. On the second day of his stay in the hospital an attempt was made to extract so far as possible the larvæ from the abscesses they had made. The opaque cornea and the sclera also of both eyes had been perforated. When the larvæ were removed from the cornea the lens came away. In a few weeks the patient died demented, though the maggots had not attained the cranial cavity.

According to Tettamanzi (*Ann. d' oculist.*, 35, p. 265, 1856) in a girl that had suffered several weeks from an inflammation of the right eye a flesh-fly maggot was removed by forceps from a fistula duct. Thereupon all symptoms disappeared. The inflammation had started at the inner angle of the eye and was accompanied by twitching and an ill-smelling outflow of pus.

The case of Thomas and Parsons (*Trans. Oph. Soc. Un. King.*, p. 14, 1909) should be noted here. The eyeball was removed and Shipley, who examined the sections into which it was cut, believed the larva to be either *Sarcophaga carnaria* or the blow-fly.

Less frequent but very violent in its attacks is *Wohlfahrtia magnifica* (=*Sarcophaga magnifica*), a flesh-fly widely distributed over Europe; and probably the most serious cases of human myiasis on that continent can be attributed to its attacks. In some instances it has been known to attack the eyes.

The oldest recorded case of ophthalmomyiasis is probably due to this species. It was recorded by Salzman in 1718; he gives a brief account of a child whose eyes had both been completely destroyed by maggots. Somewhat later Wohlfahrt (*Nova acta Acad. Leop. Carol.*, 4, p. 277, 1777) describes the case of a man of 67 in whom the right eye, the right side of the head, and the choanæ were greatly swollen and blood flowed from the nostrils. When four days later 18 large maggots came away, recovery set in rapidly. The attack on the orbit and its contents may have come from the pharynx through the tissues via the optic clefts, as in cases cited later.

The fly is found only in the open and is viviparous; hence larvæ deposited either in the nares or on the eye begin at once to burrow into

tissues and feed at the expense of the host. The fly is active during the warmer part of the day so that persons resting or sleeping in the open air at that time are especially exposed to danger of being infected.

Thus Grube and Schnee (*Arch. Naturges.*, 1, p. 282, 1853) relate a case of two boys 4 and 12 years of age who had slept in the open air and on awakening felt pain in the inner angle of the eye. The pain increased rapidly and power of sight was soon entirely lost. Examination disclosed larvæ in the inner angle of the eye which had destroyed the tissues and burrowed deep into the orbit. After 12 to 15 larvæ were removed it was found that the tissues of the orbit had been eaten so as to lay bare the optic muscles.

More recent cases appear less serious perhaps because they have received earlier attention. Lotin (*Centr. f. Augenheilk.*, Nov.-Dec., 1903) describes the removal of 10 larvæ, 5 mm. long, from a three-year-old boy. In an acute conjunctivitis of the right eye minute gray points appeared at the inner angle of the eye near the tear duct papilla; these points were in reality larvæ inbedded in the tissue. Recovery was uneventful.

Maggots taken from the orbit and from ulcers behind the ears of patients at ophthalmic hospitals in Egypt have been reported by Gough (*Bull. soc. entom. Egypte.*, p. 23, Jan., 1917) as larvæ of *Wohlfahrtia magnifica.*

The Calliphorinæ include the "blue-bottle" flies and are related to the Sarcophagidæ or blow-flies. The eggs are laid on decaying animal substances on which they feed and on sores or ulcers to which the adults are undoubtedly attracted by the odors.

Calliphora vomitoria frequently lays eggs on the eyes of children or adults and in many such cases a catarrhal condition is present. Berry (*Brit. Med. Jour.*, 2, p. 1114, Nov. 19, 1892) found in a 20-year-old male an acute inflammation of the right eyelid and conjunctiva after a fly had flown into the eye. Conditions rapidly became serious and led to complete destruction of the cornea. Serious general symptoms were associated with the attack. In the case reported by Kampherstein (*Klin. Monatsbl. f. Augenheilk.*, 1, p. 151, 1903) a peasant girl, 13 years old, was struck by a fly in the left eye. In two days the eye was conspicuously inflamed; on the fourth day the sight was gone. Enucleation was performed on the eighth day. The entire interior of the eye was filled with cicatricial tissue in the center of which was an abscess. The retina was almost gone, the other layers infiltrated with round cells and broken down. The tissue was also penetrated by fungus mycelium.

The most extreme case is doubtless that given by Schultz-Zehden

(*Berl. klin. Woch.*, p. 286, Mar. 5, 1906). A female vagabond who had lain for some time in a drunken stupor in the open field was terribly infested with fly-larvæ when brought to the hospital. Both bulbi oculi were broken down and the various structures partly or even entirely destroyed. It was almost incredible, as the author remarked, that fly larvæ could remain long enough in the eyes to effect the almost total destruction of both organs.

The larvæ of Lucilia are usually found in the carcasses of birds. In one case at least (Guzmann, *Klin. Monatsbl. f. Augenheilk.*, 48, p. 625, 1910) the larvæ of *L. sericata* were taken from both eyes of a patient suffering from acute conjunctival catarrh. The identification of the parasite was positive and the recovery of the victim rapid and complete.

Reis (*Wein. klin. Woch.*, 26, p. 889, 1913) removed 240 larvæ of Lucilia from an orbital carcinoma. The patient, a woman of 60, had suffered long from incurable cancer. The presence of the larvæ was of course no indication that they could or would have entered sound tissue.

One of the species most dangerous for man is confined to the American continent. It is the notorious American screw-worm fly, *Chrysomyia macellaria* (=*Lucilia macellaria*) which lays its eggs on wounds, ulcerating surfaces, or in fetid discharges. It is abundant in the Southern United States and in Central and South America, where it is greatly feared, as the percentage of mortality in infected cases is very high. In the majority of instances the eggs are laid in the nostrils and may affect the eyes indirectly, but cases of direct ocular infection are not wanting, though they are relatively infrequent. The cases of Eisen (See Agamofilaria eisein, herein) assigned to this parasite (by the *Centr. f. Augenheilk.*, 18, p. 447, 1894) are said by the author to be due to a filaria. Chance of confusion seems small but in any event the cases cannot belong to Chrysomyia because of their benign termination.

Not many cases reported indicate a direct attack on the eye but the following may be so construed, if the identification of the insect is correct.

Crossouard (*Arch. méd. nav.*, 31, 1894) found in the cavity of the tear sac larvæ said to belong to *Lucilia macellaria*. They were in a circumscribed cavity which does not accord with the usual burrowing habit of this species. The patient showed a small tumor at the inner corner of the right eye. When the pain grew to be intolerable the swollen tear canal was opened and 13 larvæ removed. The explanation is advanced that the fly had laid its eggs in the nose and the

larvæ had migrated into the tear sac. This view is not supported by any definite evidence.

Another case in which the larvæ of *Lucilia macellaria* were beneath the eyelids is reported by Quintano (*Cron. oftal. de Cadiz*, 1878). Like the previous case this one also seems to be wrongly diagnosed. The screw-worm maggot burrows actively into the tissues and does not rest in a limited cavity as these larvæ are said to have done. The cases may concern one of the warbleflies.

The Indian screw-worm (Pycnosoma) has similar habits. Patterson records from Assam the removal of many such larvæ from a woman and later the left orbital cavity was found packed with hundreds of maggots; the patient did not survive the attack. The larvæ of Pycnosoma give rise to "peenash," common in Rajputana; this disease is a true nasal myiasis. Rieley and Howlett (*Indian Med. Gaz.*, 49. p. 8, 1914) describe cases as follows:

Case I. "The patient on coming to the hospital presents a characteristic appearance of having a diffused edematous swelling about the upper part of the face, more or less localized at the nose, eyes, lower part of the forehead, and upper lip. The swelling about the eyes often being sufficient to reduce the palpebral fissures to mere slits, and thus impairs vision temporarily. The patient complains of an intense burning and gnawing pain in the affected parts, associated frequently with the feeling of maggots being present in them. "The larvæ may work up the nasal duct and emerge through the conjunctiva of one or both eyes."

Case II. "Emerging from the ulcerated surfaces (soft palate) could be seen scores of larvæ actively engaged in devouring the soft tissues, some of which were found passing through the nasal ducts of both sides and emerging through the palpebral conjecturæ."

OCULAR PARASITES FROM OTHER HOSTS

In 1832 von Nordmann published his famous work, *Mikroskopische Beiträge*, in which were included the descriptions of human ocular parasites noted above. He devoted other sections of the book to similar parasites in other mammals, in birds, in amphibians, and in fishes. Even at that early date he was able to list 13 species which he himself had studied, the majority of which had been obtained from the eye of various fresh-water fish. The list he gave was by no means complete even for that time and has grown much since then. Without attempting to give a complete census of such forms, or even to refer to all the important species that infest the eyes of various vertebrates,

it may be permitted to mention some of the more important groups of ocular parasites from other hosts than man.

Many of the domestic animals suffer from the attacks of the same ocular parasites that are found in the human host. *Cysticercus cellulosæ,* discussed above as a human parasite, has been reported from the eye of the pig also. Several filarias found rarely in man are common in the larger mammals in certain regions; no doubt they reach the human eye because they develop abundantly in other hosts and infect the territory. *Filaria conjunctivæ* is an abundant parasite of the horse and ass in southern Europe where infrequent cases have been reported from the human host, as described above. The filaria Stuckey recently reported from China was also found at about the same time in the eye of a dog. Similar parasites occur often in cattle, mice, etc. Man owes a large percentage of his parasitic infection to species that primarily attack other hosts.

One may be slightly surprised in looking up a title like "Case of *Filaria oculi* occurring in practise; operation and recovery (*Canada Med. Rec.*, Montreal, 1, p. 173, 1872) to find that the patient was a bay mare! But this equine parasite was unquestionably a menace to the human host also and such records recur with greater frequency in medical literature as time advances. Only adequate knowledge of parasites from other hosts will enable us to handle new cases and prevent the occurrence in man of forms known elsewhere.

Birds also are generously infected with ocular parasites. Ransom (*Bull.* 60, *Bur. Animal Industry,* 1904) described for North America Manson's eye worm of chickens, *Oxyspirura mansoni,* and listed in the same paper 38 species of Nematodes alone that have been reported from the eyes of 43 different species of avian hosts. These Nematodes often provoke a severe ophthalmia which untreated leads to the loss of eyesight or even of the bird itself. Railliet and his colleagues have done much work on the Nematodes parastic in the eye, and have monographed types that infect the lachrymal glands of the horse and cow, and that live within the nictitating membranes of birds.

Aquatic animals are not as likely to be infected with Nematodes as with other ocular parasites, but have a much larger number of such assailants in all. The forms concerned among fish are mostly Trematodes, of which many species have been reported from various regions and hosts.

Greeff found in the lens in fishes developmental stages of Trematodes and stated that epidemics of blindness, especially in standing water, are well known to fish culturists. In Lake Geneva trout have been observed that lost appetite, became blind and perished as a result

of such epidemics. Gulls that sheltered Trematodes in the alimentary canal had infected the waters by their fecal masses. The larvæ bore through the intestinal wall and by use of blood vessels reach the eye.

As stated above this author regards these as capable of being transferred at times to the human host and of gaining access then to the optic organs.'—(H. B. W.)

Many useful clinical observations on these animals will be found under various other headings in this *Encyclopedia*, for instance under **Cysticercus**, p. 3661, Vol. V.; **Filaria**, p. 5194, Vol. VII.; **Echinococcus**, p. 4123, Vol. VI.; also under **Hookworm**, p. 6001, Vol. VIII., and p. 487, Vol. I. Several other minor captions, such as **Beef worm**, p. 922, Vol. II, and **Larval conjunctivitis**, p. 7018, Vol. IX., may also be consulted.

Other references pertaining to this subject will be found herein as follows: Vol. I, p. 638; Vol. IV, p. 2523; Vol. V, pp. 3582, 3814, 3840; Vol. VI, pp. 4048, 4049; Vol. IX, pp. 6685, 6687, 7039; Vol. X, pp. 7447, 7542, 7868; Vol. XI, p. 8472.

Wintersteiner (*Encyklopädie der Augenheilk*, p. 662) gives the following general classification (see **Comparative ophthalmology**) of ocular parasites, viz., *epizoa*, those that infest only the superficial coverings (skin, conjunctiva) of the eye, and *entozoa*, that burrow into the deeper structures.

The occurrence in the conjunctiva of parasitic growths due to the *Rhinosporidium* (of Kinealy) is very unusual. Elliot and Ingram (*Ophthalmic Year-Book*, p. 354, 1912) report such a case of five years' duration occurring in a 60-year-old male. Examination revealed a pendulous semicircular cutaneous over-growth loosely overhanging the upper part of the superior maxillary bone, measuring 20x13 mm., and 9 mm. thick. Eversion of the lower lid discovered a second mass on the outer two thirds of the palpebral conjunctiva of a reddish granular appearance with patches on it. Large tortuous vessels coursed over it and on pressure thick creamy pus escaped from the follicles. A third mass, situated close to the inner canthus and apparently extending into the orbit, contained fluid. All three tumors were removed, and all contained cysts of Rhinosporidium Kinealyi, the orbital one containing by far the most.

Ingram also refers to two other cases that fell under his observation and states that the nose and pharynx are a much more favorable nidus for the parasite than the conjunctiva. Kirkpatrick in a report supplementary to the above communication, records two more cases both

affecting the conjunctiva. He remarks that rhinosporidium affecting the nasal passages always has a very characteristic appearance, forming as it does long finger-like processes having semitransparent edges and a band of fibrous tissue running down the middle like the midrib of a leaf.

W. Reis (*Tygodnik lekarski*, Nov. 11, 1912) refers to the literature of *larval conjunctivitis, keratitis and iritis*, and instances of their occurrence from the initiation of the larvæ of various flies, especially of *Musca vomitoria, Lucilia hominivorax, Sarcophaga, Calliphora and Hypoderma bovis*. These were found in the conjunctival cul-de-sac, in the lachrymal sac and even in the anterior chamber. The author also described an old woman, poor and badly nourished, in whom he found at the bottom of an orbital ulcer, 240 larvæ of *Lucilia hominivorax*. Later he encountered another case of ocular miasma in a man aged 43. From the conjunctival sac of this patient he secured a larva belonging to the variety *Eristalis tenax* which derives its name from its surprising immunity against even the strongest poisons, flourishing, the writer states, in the mud of sulphur springs. It may be immersed without perishing in a saturated solution of corrosive sublimate for eight hours and in pure formalin for twelve hours.

Paraspecific. Having therapeutic value apart from its specific one.

Parasympathetic ophthalmia. See the end of **Keratitis, Atypical,** p. 6760, Vol. IX of this *Encyclopedia*.

Parasyphilitic. Relating to a result or sequel of lues but not to the infection itself. See, for example, the parasyphilitic diseases, **Tabes dorsalis,** also 8357, Vol. XI; as well as **Paresis, General.**

Paratonia. Excessive extension; hyperextension.

Paratonic. Relating to that action of light by which vegetable growth is retarded.

Paraxial rays. In *optics*, the rays that are incident within a very small area around the vertex of the surface of a lens or mirror.

Parcel camera. A camera made up as an ordinary brown paper parcel.

Pardee, E. H. A well known San Francisco ophthalmologist. The date and place of his birth are unknown. He lived, however, in Oakland for more than thirty years, and practised ophthalmology and otolaryngology in San Francisco. He was a very public-spirited man, a leader in politics in Alameda County, and once was mayor of Oakland. He became very wealthy and died possessed of a great deal of Oakland real estate, notably a large business block on Broadway. He died at his residence in Oakland, Sep. 22, 1897.—(T. H. S.)

Paré, Ambroise. He is often called the "Father of Modern Surgery," for, though a barber, the son of a barber, and never a highly educated

man, his natural ability and great inventiveness caused him to exercise an overwhelming influence over the mechanical division of the healing art—an influence which lasts even to the present day. He was born in 1509 (1510?) at Bourg-Hersent, near Laval, France, entered not a college but a barber-shop, and thence passed to the great Hôtel Dieu, still later to the field of battle. It was while in the service of the Marshal Monte-Jan that the accidental lack of hot oil suggested to this ingenious man the method of arresting hemorrhage by the ligature of injured vessels. He was really, however, not the inventor, but only the re-inventor, of this now universally employed procedure. Among the other things for which Paré will always be remembered, are these: He re-invented trusses; herniotomy for strangulated hernia, and the figure-of-8 suture for harelip. He invented the operations of staphyloplasty and bronchotomy, and was probably the "first to perform excision of the so-called 'loose cartilages' in joints." Ophthalmologically he is, like his younger contemporary, Fabricius of Acquapendente, not of very great importance. Most of his ocular surgery he takes directly from the ancient Greeks and the Arabians, and, often, he is greatly at fault in so doing, selecting the worst rather than the better, modes of procedure. This is notably the case in regard to the cataract operation.

He describes a kind of eye-speculum, however, which is really adjustable, and, to that extent, an improvement on the specula of previous inventors. For squint he recommends the strabismus-mask of Paulus, as well as spectacles of horn with a hole in each disk.

Paré did not really invent the artificial eye, though often declared to have done so. In fact, he himself nowhere claims priority in this matter. The history of the *prothesis oculi* is, very briefly, this: The ancient Egyptians placed artificial eyes in mummies, but never in the heads of living people. The ancient Greeks and Romans made use of a similar affair in statues, the person who made or sold such eyes being called *ocularíarius* (not *ocularius,* which meant "oculist"). In the Jerusalem Talmud, Nedar, ix, there is a passage which, apparently, refers to the artificial eye, but which is often said by competent authority to be either a corrupted, or an interpolated passage. Finally, somebody (nobody now knows who) invented the modern *prothesis oculi,* and this artificial eye Ambroise Paré did much, no doubt, to render poular.

In a word, the relation of Ambroise Paré to the invention of the artificial eye was probably much the same as that of Alexander de Spina to spectacles.

Paré died, aged 80, Dec. 20, 1590.—(T. H. S.)

Parenchymatous iridochoroiditis. Purulent iridochoroiditis.

Parenchymatous iritis. That form of the disease in which the iris is much thickened, infiltrated and distorted. See p. 6668, Vol. IX of this *Encyclopedia*.

Parenchymatous keratitis. See p. 6789, Vol. IX of this *Encyclopedia*.

Parenchymatous retinitis. Hyperplastic form of the disease. See **Retinitis, Parenchymatous.**

Parenole. A name given by Humphrey (*Pharmaceutical Journ.*, p. 623, 1906), to a new series of ointment bases, which have a salve-like consistency and possess the property of taking up more than their weight of water. They are also miscible with any of the fats. A fluid parenole is also made, which constitutes a neutral liniment and may be used as a lubricant, as a vehicle for subcutaneous injections. They ought to be valuable in ocular therapy.

Paresis. Incomplete paralysis, especially when not associated with any demonstrable organic change.

Paresis, General. Softening of the brain. Paralysis of the insane. Dementia paralytica. Meningoencephalitis. Progressive general paralysis. A short account of the ocular symptoms accompanying this disease is given on p. 6370, Vol. VIII, and a more extended one on p. 8352, of this *Encyclopedia*. It may here be added that A. Rodiet and P. Pansier (*Receuil d'Ophtalm.*, Oct., 1909) point out that Reznikow, Hirschberg and Galezowski consider general contraction of the field of vision as one of the earliest signs of general paralysis, while others (e. g., Joffroy, Sauvineau and Schrameck) affirm that it is only an apparent contraction, the mental condition of the patients rendering a perimetric examination a matter of considerable difficulty. Again, it is stated by others that this combination of the visual field is common in toxic conditions, e. g., alcohol, tobacco, etc., which are often precursors of general paralysis, and after their own experiences Rodiet and Pansier favor this view themselves. Several writers (Charcot, Parinaud and Blocq) have thought that another symptom of the early stage of general paralysis is ophthalmoplegic migraine; while others see nothing at all characteristic about the occurrence of this condition and regard it as a coincidence.

A general scotoma has sometimes been recorded but this is by no means constant. With regard to the lesions associated with these visual troubles, many have been described though several of them can hardly be considered peculiar to general paralysis. The combination of amblyopia with negative fundus changes, a sort of papillary edema (Galezowski), tortuosity of the retinal vessels, (Voisin), degenerate lesions in the vessels (Klein), atrophy of the nerve (Bay, Bouchet,

Magnan), are a few of the ophthalmoscopic appearances which have been considered important.

The examination of these cases histologically reveals a condition of connective tissue development in the retina and around the blood-vessels (Magnan), eventually spreading to the optic nerve, when it produces what Reznikow describes as an interstitial optic neuritis which ultimately leads to atrophy. As a result of these observations, the authors have formed the opinion that the ordinary amblyopia of general paralytics is a retrobulbar neuritis which progresses slowly and finally leads to atrophy of the optic nerve; and when visual defects are accompanied by lesions in the fundus, the latter are variable and in no way characteristic.

C. B. Welton (*Ill. Med. Journ.*, Jan., 1914) reporting on 50 cases of *general paralysis of the insane* finds that *ptosis,* partial in degree, occurs in paresis in a small percentage of cases, is a symptom of the late stages of the disease, and is of no great diagnostic importance on that account.

Ocular palsies are present in about 10 per cent. of the patients; occur late in the disease and are of no especial interest.

Inequality of the pupils is found in half of the cases of paresis. It is, if not the first, one of the earliest symptoms to appear, and is of undoubted diagnostic value.

Distortion or misshaping of the pupil occurs in a certain percentage of cases in the prodromal stage of paresis and reaches in patients in the later stage a high percentage. It is only of relative importance.

Reflex iridoplegia and diminution in the light reaction are of great diagnostic importance. The Argyll Robertson pupil is a cardinal eye symptom of the disease, reaching, aside from tabes, its highest percentage in general paralysis. It appears early in the disease in about one-third of cases.

The consensual light reaction is absent in about one-quarter of the cases in the early stage of paresis, and is absent in practically all of the cases in the terminal stage. Alone, it has not much diagnostic significance.

Vision, together with the color-sense and visual fields, is generally normal in paralytics, at least in the early stages.

There are no fundus changes which are indicative of paresis with the exception of optic atrophy, which occurs in 5 to 10 per cent. of cases in the last stage of the disease.

Paresis of accommodation. See **Accommodation, Weakness and paresis of.**

Paresis of the ocular muscles. See **Muscles, Extrinsic ocular; Pupil, The, in health and disease**; as well as **Ophthalmoplegia.**

Parfait-Landrau. A well known French ophthalmologist. See **Rivaud-Landrau.**

Parhelion. An intensification of a circular space in a solar halo.

Parietal lobe, Tumors of the. These new growths rarely give rise to any ocular symptoms except, occasionally, a papillitis. Wernicke has reported three cases of conjugate lateral deviation, while if the internal capsule be implicated hemiopia may result. See **Brain tumor,** as well as **Choked disk.**

Parinaud, Henri. A celebrated Parisian ophthalmologist, the first to describe "Parinaud's conjunctivitis," and a profound student of the eye

Henri Parinaud.

in its relation to the general nervous system. Born at Bellac, Haute Vienne, France, May 1, 1844, son of a very poor locksmith, he received his earliest education in a school of the brothers of charity. From 1857 till 1863 he studied at the Seminary of Ajain. His father having died in the last-named year, on the shoulders of the 19 year old boy developed the duty both of giving himself a liberal education and also of assisting his widowed mother and his two or three orphaned brothers in securing the necessities of life. Having undergone numerous hardships, he received the degree of Bachelor of Arts at Poitiers, and commenced the study of medicine at Limoges.

In 1869 he received at Paris the externship in some hospital, but soon

was enlisted in the war against Germany. Though a man of delicate health, he showed the greatest bravery throughout this war, as well as the utmost devotion to his patients. His unparalleled conduct at Chateaudun was afterward celebrated by the writer, Ludovic Halévy.

Returning to Paris, Parinaud received the doctorate in 1877, submitting as his graduating thesis "Etude sur la Névrite Optique dans la Méningite Aigue de l'Enfance." Before this time he was chief of the clinic for Galezowski. After a time he established in one of the poorer quarters of the city a gratuitous ophthalmic cline—which at first was on the Rue de la Condamine, then on the Avenue de Clichy, and, finally, on the Rue Ballu. At this clinic were frequently present students and practitioners from various portions of the world. He never held a professorship.

Parinaud's constitution, which was never strong, received a very great shock in the death of his wife, in Sept., 1904. In the following February he was stricken with broncho-pneumonia, and died Mar. 23, 1905.

Parinaud's writings, which are very numerous, are listed in full in the *Annales d'Oculistique,* Vol. 133 (1905) pp. 334-337.—(T. H. S.)

Parinaud's conjunctivitis. Lymphoma of the conjunctiva. In addition to the meagre account of this peculiar and uncommon disease on p. 3124, Vol. IV, it may be said that a reference to its bacteriology will be found on p. 832, Vol. 11 of this *Encyclopedia.*

Gourfein (*Révue Gén. d'Ophtal.,* Feb. 28, 1907) believes this rather rare disease to be decidedly infectious. The author studied eleven cases bacteriologically and six cases experimentally. He reports a case which he had the opportunity of studying both clinically and bacteriologically. It was that of a young man, a shoemaker, first seen Oct. 15, 1904; patient complained of trouble in right eye; health poor, having had fever and chills at night; no cough or expectoration; respiration normal; no thoracic or other symptoms. The right upper eyelid was much swollen, red and edematous with partial ptosis and little mobility; right lower lid also swollen, but not quite to the degree of upper lid. Eversion of the lids showed turgidity of the palebral conjunctiva and cul-de-sac which were covered with gray granulations of oval form and various sizes; bulbar conjunctiva hyperemic; secretion abundant and somewhat purulent; cornea transparent and presented nothing abnormal; lachrymals normal. Vision 5/v. All the facial ganglia of right side (pre-auricular, retro- and submaxillary and the parotid) engorged, hard and painful to the touch; the skin was red and glossy. The adenopathy preceded the ocular lesion by five days; it disappeared without suppuration after the conjunctival cure. The

topical treatment consisted in cauterizations of the conjunctiva, with a 2 per cent. nitrate of silver solution, hot compresses to the lids, hot cataplasms to the ganglia, and internally cod liver oil. Patient left the hospital cured Nov. 1, 1904. The adenitis persisted six weeks.

The clinical aspect of the conjunctival lesions, the adenitis and the fever which the patient had, indicated to the author that the case was one of acute tuberculosis of the conjunctiva, and it was with the object of proving the tubercular nature of the disease that he undertook the bacterial investigation of the case. When the patient was admitted to the clinic the conjunctival secretion was examined microscopically, the staining being made with the Ziehl and Gram methods, but no tubercle bacilli were found, though many of the ordinary saprophytic organisms were seen which frequently inhabit the healthy conjunctiva. Eight tubes of potato, two of glycerin agar and four of the serum of Loeffler were inoculated with the conjunctival discharge and placed in the culture oven, which latter was kept at 37 C. The tubes of Loeffler serum and the glycerin agar, examined after 36, 48 and 72 hours, presented grayish colonies, more opaque in the center than at the periphery, and other colonies more numerous, which were whitish. The first were composed of xerobacilli of different dimensions which when injected into the anterior chamber of a rabbit's eye, produced a slight turbidity of the aqueous and iridic hyperemia, which soon disappeared without treatment. The whitish colonies contained staphylococcus albus, and when injected into the rabbit's interior chamber similar symptoms resulted. No tubercle bacilli were found in the cultures and the animals inoculated presented no signs of tuberculosis. Gourfein believes that this infectious disease is caused by a microbe as yet undiscovered.

In Scalinci's (*Clinica Oculistica,* p. 37, 1909) interesting review of the sixty cases published to that date he speaks of it as "still attributed to some infection from the lower animals." As knowledge of the disease has increased it has become more difficult to maintain this theory of its causation, first advanced by Parinaud, as seems to have been urged for the first time by Gifford; it is only fair to say, however, that a few observers cordially agree with Parinaud, and have in a number of cases brought forward facts which go to corroborate the original explanation, though in Scalinci's opinion these "facts" are not particularly convincing—suggesting coincidence rather than an actual casual relation.

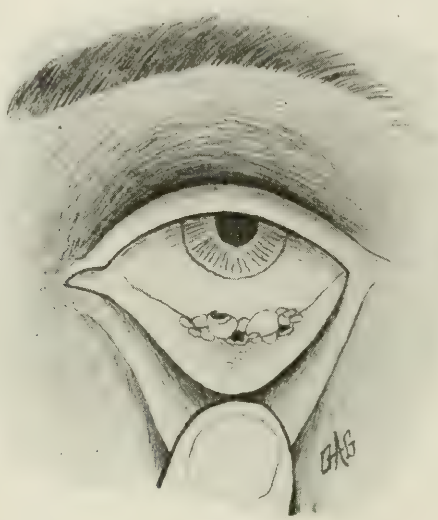
In one of the recorded cases examination failed to show any organisms, in at least one other the tubercle bacillus was to be found; in others staphylococci have been found, in one pseudodiphtheritic

bacillus, and in one a bacillus related to that of fowl-cholera. In regard to this however, it is right to mention that conjunctival inoculation of the organism and its introduction into the scarified cornea of a guinea-pig produced nothing even suggestive of the disease.

The author does not think that the discovery of the streptococcus and the staphylococcus takes us very far towards the complete understanding of the disease. It is difficult to suppose that either of these could be the cause of a unilateral disease, considering the ease with which these microbes can be conveyed to the other eye, while Parinaud's disease is essentially unilateral; but if we assume that for some unknown reason the organisms had penetrated more deeply than usual into the tissues we may perhaps have a clue to the solution of this difficulty and to that of the occurrence of the lymphadenitis also. In conclusion Scalinci advocates a change of nomenclature to Parinaud's disease, indicating that in the syndrome or group of symptoms we have something more than a mere conjunctivitis with peculiarities.

The *Ophthalmic Year-Book* for 1909 mentions several reported cases. Sinclair and Shennan report a case which occurred in a man 61 years of age, with the well-known symptoms of this disease, namely, swelling of the preauricular and submaxillary glands, and to some extent also the cervical glands in front of the sterno-mastoid, and the development of distinct swellings or nodular masses on the conjunctiva, and they discuss its pathology, especially in its relation to the presence of the plasma cell. The histological changes depend on the formation in the subepithelial tissue of a variety of granulation tissue, crowded with cells and containing numerous young blood-vessels. There are also alterations in the epithelium, with superficial erosions and minute areas of necrosis in the deeper tissues. In these respects their results correspond more closely with the observations of Verhoeff and Derby than they do with those of Reis, who denies the presence of a necrotic process. Plasma cells predominated in the sections prepared by Sinclair and Shennan, and the appearances observed support the theory that the plasma cells are chiefly derived from lymphocytes by a process of enlargement of the nucleus and of the protoplasm. Many of the lymphocytes, according to these authors, had emigrated from the small bloodvessels and subsequently undergone progressive development. Cultures from the necrotic areas yielded two varieties of white staphylococci, and from the suppurating glands in the neck staphylococcus albus and aureus were separated, and from one sinus streptococci. The authors attempted to institute vaccine treatment, but the patient did not remain long enough under observation to state with accuracy any results from this form of medication.

Schoeler reports a case of Parinaud's conjunctivitis in an infant of 1½ years. After eight days of insomnia, chills and depression, a swelling of the eyelids of the left eye was noticed, with corresponding adenopathy. The palpebral conjunctiva was inflamed, thickened, and covered with yellowish granulations. The bulbar conjunctiva was merely injected. The cornea was not involved. The preauricular ganglion was of a semi-fluctuating consistency, and the parotid region was puffy. There was no fever, no glandular suppuration, and no modification in the appearance of the lesions during the three weeks of observation. No bacteriologic or histologic examination was made.



Parinaud's Conjunctivitis (Griffin.)

Bassères and Poujal report a case presenting all the characteristic features of Parinaud's conjunctivitis and the positive exclusion of conjunctival tuberculosis. This is one of very few cases, however, in which a corneal lesion has been reported. This lesion took the form of a vegetation, starting from a supracorneal, chemotic swelling, encroaching upon the cornea, and attaining the size of a large lentil. Beneath this vegetation an anterior synechia was formed.

In reporting two cases of Parinaud's conjunctivitis, Barck records a treatment which he had found efficacious, namely, the removal of the excrescences with scissors, squeezing out the yellow infiltrates with a trachoma forceps and the daily application of a 1 per cent solution of sulphate of copper.

Wilder's patient exhibited the clinical symptoms of Parinaud's con-

junctivitis, but in the discussion of his case it was suggested by Brown that it might be a case of tuberculosis, and in a similar lesion which had been examined by Snydacker in a boy aged four years, smears demonstarted the presence of the tubercle bacillus.

Oppenheimer also reports an unusual case of Parinaud's conjunctivitis, and Lawson a case under the same title, which, however, he questions, although the symptoms seem to conform to this type of disease. Nothing characteristic was found in the lesions, which were examined microscopically by Coats, which could suggest tubercle or trachoma. Calmette's test was not tried.

Krusius and Clausen (*Arch. f. Augenheilk.*, p. 327, 1912) report two cases of Parinaud's conjunctivitis in which the symptoms were typical: fever, glandular enlargement in the neck and in front of the ear on the affected side, and nodules in the palpebral conjunctiva. In each case the nodules were associated with a coxcomb-like swelling of the conjunctiva of the lower lid. In one case the disease was apparently grafted upon an old kerato-conjunctivitis. In both instances the Von Pirquet test was positive, although in one patient only at the second trial. The subcutaneous tests produced marked general, but no local, reactions. Repeated conjunctival instillations of tuberculin in increasing doses were followed by no trace of local reaction. Inoculation tests with guinea pigs feebly but definitely indicated the presence of tuberculosis. The course of the disease, and the results of the tuberculin and inoculation tests, favor the conception of Parinaud's conjunctivitis as a local re-infection with tuberculosis, occurring in individuals who have acquired relative immunity from a previous infection.

The absence of local reaction to tuberculin, in spite of the presence of general reaction, is against the possibility of the conjunctival infection being the primary source of the allergistic changes in the serum. Failure to produce a local reaction by the instillation of tuberculin on the other hand, may be explained by supposing that the natural production in the diseased tissues of large quantities of tuberculin precluded any reaction to the small amount introduced artificially.

Rolande (*Ophthalmic Year-Book*, p. 113, 1916) records a case of this disease, and gives the syndrome drawn from a review of 111 cases found in literature. The disease has a predilection for young persons. Twenty-five occurred in children below 10 years. Systemic disturbance ushers in the disease, either preceding or concurring with the development of the conjunctival lesions. One eye is usually alone involved; although in seven cases the condition affected both eyes either simultaneously or after an interval of time. The conjunctiva may have a

general swollen appearance with the surface divided by broad and deep sulci; or characteristic granulations having their seat by predilection in the conjunctiva of the tarsus and fornices, and also appearing on the bulbar conjunctiva, may occur. Their size varies from a pin point to that of the largest trachoma granule. In the acute period they may résemble either the follicle of follicular conjunctivitis or of trachoma. They are usually of a yellowish color.

The granulations may give rise to formations resembling raspberries or coxcombs, in which case they are usually sessile. They may later resemble the flat granulations of vernal conjunctivitis. Occasionally they assume a polypoid aspect. Erosions frequently covered by a yellowish white exudation or by a pseudomembrane now and then exist. The bulbar conjunctiva is, as a rule, normal. The secretion is usually mucopurulent in character. The cornea is rarely affected, although pannus with minute ulcers has been met with. The homolateral lymph glands are swollen. The order of their involvement being the preauricular, parotid, submaxillary and cervical. In rare instances the lymphatics of both sides are involved. Caseation occurred in thirty-two cases. The duration of the disease is from 2 months to 2 years. Rolandi concludes that Parinaud's conjunctivitis is not a distinct entity, but rather a clinical syndrome; and in its classic form is a special type of tuberculosis of the conjunctiva, characterized by an exceptionally benign course and by spontaneous recovery. It has not yet been demonstrated whether this tuberculous form is due to human or bovine tuberculosis.

Parinaud's dermo-epithelioma. See p. 3840, Vol. V of this *Encyclopedia.*

Parinaud's syndrome. Mosso, (*Ophthalmic Year-Book*, p. 100, 1913) writing on this subject cites the following case:' The patient was a woman of 45 years who, with violent headache, vertigo and nausea, developed a diplopia. There were slight ptoses and limited excursion of the right upper lid. The pupil, although contracted, reacted to light but not to accommodation or convergence. Associated movement of the eyes outward produced oscillatory nystagmus in both eyes. The power of convergence was entirely absent in the right and was limited in the left. Diplopia was spontaneously manifest at a distance of 50 cm. or less, and became constant with the use of the Graefe prism or Maddox rod test. The left eye read 0.5 Snellen at 25 to 42 cm., whereas the right was only able to do so with a lens of plus 3.50 to 4.00 D. The symptoms disappeared under mercury.

Paris quadrifolia. ONE-BERRY. TRUE-LOVE. FOUR-LEAVED GRASS. A species of plant found in moist, shady places in most parts of Europe.

The herb and root furnish paradin. All parts of the plant are more or less acrid and poisonous. The juice of the leaves has been employed in chronic inflammation of the eyelids.

Parker, James Pleasant. The founder and for many years the editor of the *Annals of Ophthalmology and Otology*. Born in Alabama in 1854, he studied and practised pharmacy for a few years, and then began to devote himself to medicine. His medical degree was received from Jefferson Medical College in 1886. In 1886 and '87 he studied ophthalmology and oto-laryngology in Philadelphia and New York, and late in 1887 settled in Kansas City. In 1891 he began to publish the *Annals* and the following year removed to St. Louis. In 1896, however, on the 26th day of February, he died.

The pathetic story of Parker and his connection with the journal to which he gave his life, can best be told in the language of the Editor, Casey Wood, in the *Annals* itself for January and April, 1896: "As a result of Parker's ceaseless industry and good management this literary venture was successful from the beginning, but, unfortunately, Parker lost all his money by the failure of a Kansas City Bank, just at the critical moment when he moved to St. Louis, in 1892. Instead of being discouraged by this disaster he seemed to regard it merely as an incentive to greater efforts. Henceforth, although his health was never very good, he worked literally day and night to advance the interests of the journal, and, as his friends afterwards discovered, denied himself, for many months, even the ordinary necessaries of life that the *Annals* might be regularly issued and present a creditable appearance. This necessity for the practice of a close economy forced Parker to forego the pleasure and profit of attending medical meetings and prevented him from cultivating the acquaintance of many brother ophthalmologists, although well-known to these through the interchange of letters.

"These deprivations and the lack of proper rest and recreation doubtless contributed to the fatal termination of an attack of pneumonia, which he acquired in December of last year. In spite of all warnings he persisted in his labors until the last; indeed, his attendants believe that the January number of the *Annals* was gotten out at the expense of his life.

"While more notable sacrifices of all that men hold dear have ere this been made in the temple of medicine, surely few worshippers have given of their substance more freely, more fully and with less complaint than this devoted practitioner of our art!"—(T. H. S.)

Parker-Verhoeff modified charts. See p. 2009, Vol. III of this *Encyclopedia*.

Parkinson's disease. See **Paralysis agitans.**

Parnassia europea. PARNASSIA PALUSTRIS. This "grass of Parnassus" is a species growing in wet meadows throughout Europe, Northern Asia, and parts of North America. The herb and flowers were formerly used as a diuretic and in ophthalmia.

Parodyne. See **Antipyrine.**

Parophthalmia. Inflammation around the eye.

Parophthalmoncus. (Obs.) A swelling or tumor around the eye.

Paropia. An old term for the inner canthus.

Paropion. PAROPIUM. A screen for the eyes.

Paropsis. Disorder of the sense of vision; any anomaly of eyesight.

Paropsis glaucosis. A name for *glaucoma.*

Paropsis longinqua. (Obs.) Presbyopia.

Paropsis lucifuga. Nyctalopia.

Paropsis noctifuga. Hemeralopia.

Paropsis propinqua. Myopia.

Paropsis staphyloma simplex. Hydrophthalmia.

Paropsis staphyloma purulentum. Hypopyon.

Paropsis strabismus. A name for strabismus.

Parorasis. Color-blindness.

Parotiditis, Ocular relations of. See **Mumps,** p. 7876, Vol. X of this *Encyclopedia.*

Parrot's sign. Dilation of the pupil on pinching the skin of the neck; seen in meningitis.

Parry's disease. Exophthalmic goitre. See p. 4805, Vol. VI of this *Encyclopedia.*

Pars ciliaris retinæ. See p. 390, Vol. I of this *Encyclopedia.*

Pars iridis (iridica) retinæ. See p. 390, Vol. I of this *Encyclopedia.* This tissue is really an extension of the *pars ciliaris retinæ,* the retinal elements in the iris.

Pars non-plicata. One of the divisions of the ciliary body.

Pars orbicularis palpebrarum. Orbicularis palpebrarum muscle.

Pars plicata. A division of the ciliary body.

Pars uvealis corneæ. A term applied to the developmental structures that, about the third month of fetal life, represent the *ligamentum pectinatum* and Descemet's membrane.

Parthians, The. The ancient Parthians, according to the accounts of the Romans, were mostly to be feared when in full flight. Each armor-clad horseman, as the story has come down to us, carried upon his back "a reflecting plate of metal." The horseman next behind, looking into this mirror, took aim by its aid alone, and, shooting backward over his left shoulder, was wonderfully effective.—(T. H. S.)

Partial cataract. An incomplete, immature cataract; an opacity which does not involve the entire lens.

Parti-colored. PARTY-COLORED. Variegated in color.

Partridge, The. The gall of a partridge was highly esteemed by Hippocrates for corneal scars and various injuries of the eyes. Dioscorides extended the application of the remedy to corneal ulcers and various affections, acute and chronic, of the lids. It seems to have been important to keep the gall inclosed in a silver box.—(T. H. S.)

Parturition, Ocular injuries during. See **Birth injuries,** p. 999, Vol. II; also **Amblyopia from hemorrhage,** p. 292, Vol. I of this *Encyclopedia.*

Paruria erratica. A condition in which urine is discharged from abnormal passages. In a case cited the discharge was from the eyes, ears, breast. See *Am. Jour. of the Med. Sci.,* p. 49, 1827.

Pasque-flower. See **Pulsatilla.**

Passages, Lachrymal. Properly, the excretory ducts of the lachrymal gland; the puncta, canaliculi, lachrymal sac, and nasal ducts.

Passavant, Gustav. A well-known German surgeon, of moderate ophthalmologic importance. Born Jan. 28, 1815, at Frankfort-on-the-Main, he studied at Berlin and Vienna, at the latter institution receiving his degree in 1840. From 1843 until his death he practised in his native city, being widely known as a surgeon. He was made Privy Sanitary Councillor shortly before his death, which occurred Aug. 28, 1893.

His only ophthalmologic writing was "Methode der Korelyse" (*Arch. f. O.,* XV, i, 259-264, 1869).—(T. H. S.)

Passiflora serrata. An Antilles species of the *passion flower.* The leaves are employed as an antiscorbutic and in angina, and an infusion of the flowers in ophthalmia.

Passions affecting the eye. See, for example, **Fear, Ocular signs of,** p. 5175, Vol. V of this *Encyclopedia.* See, also, in this connection, Darwin's *Expression of the Emotions in Man and Animals.*

Passive plane. In *optics,* the section of a prism or cylindric lens which is a parallelogram indifferent to refraction and at right angles to the active plane (q. v.). In a cylindric lens it coincides with the axis of the cylindric surface.

Paste, Beck's. See **Paste, Bismuth.**

Paste, Bismuth. This is a mixture of 1 part of bismuth subnitrate in 2 parts of vaselin injected for the treatment of tuberculous sinuses and cavities.

Van Lint of Brussels (*La Policlinique,* Feb. 1, 1912) injected it into the lower canaliculus of a young girl affected with tuberculous dacryo-

cystitis accompanied by a fistula of the skin. The parts were healed in a fortnight.

Paste, Esmarch's. A caustic paste used in the treatment of cancerous and other growths; made of 1 part of arsenic, 1 of morphin sulphate, 8 of calomel, and 48 of acacia.

Pastes for eye diseases. See **Argilla,** p. 564, Vol. I of this *Encyclopedia.*

Pasteurization. This term has been applied by Prince (*Ophthalmic Record,* April, 1916) to the principle of Meekers. He reports ten cases to which he applies a red heat in the treatment of corneal ulcers. Like Darier, he made no bacteriologic examination, as he claims that the treatment, properly administered, kills all bacteria without destroying the corneal tissue, and relieves pain as well. Instead of using the heat from a galvano-cautery point, as Meekers had done, he has devised a "pasteurizer" which is a slight modification of Todd's cautery. The end of the instrument is held over a flame until it is red hot. The heated ball is then held about three-sixteenths of an inch from the ulcer, until it cools. To acquire familiarity with the amount of heat which actually reaches the cornea, it is well to approximate the heated end to the bulb of an ordinary thermometer. The temperature should not register more than 150°.

Five additional cases are also reported by Gilbert with excellent results, using the method recommended by Prince. In two of his cases, all previous efforts with drugs had been of no avail. He uses the heat three times a day.

Pasteurizer. A name given by A. E. Prince (*Ophthalmic Record,* p. 178, April, 1916) to an instrument for the treatment (without actual contact with the lesion) of corneal ulcers by heat.

Patch, Hutchinson's. Salmon patch. A reddish or salmon-yellow patch of the cornea in syphilitic keratitis. See **Keratitis, Parenchymatous.**

Patches, Mucous. See **Mucous patches,** p. 7873, Vol. X of this *Encyclopedia.*

Paternostererbsen. (G.) Jequirity.

Patheticus nerve. The fourth nerve, supplying the *patheticus* muscle, the superior oblique.

Pathogenesis. Origin of disease.

Pathology of the eye. This subject has been treated under the headings that comprise the various ophthalmic diseases and pathogenic processes treated in this *Encyclopedia;* and particularly under such major captions as **Bacteriology of the eye; General diseases; Neurology of the eye; Iritis in general; Choked disk,** etc.

Paul of Ægina (hence, **Ægineta**). A famous surgeon, obstetrician and

ophthalmologist of the Greek middle ages. The dates of his birth and death are not precisely known, but he undoubtedly flourished in the first half of the seventh century. Baas sets the limits of his life as 625-690 A. D.; on the other hand, as pointed out by Handerson, "if the date assigned [by Baas] for the birth of Paul is correct, he could have been but sixteen years old when Alexandria was captured—an age when his medical education at least could have been scarcely begun." We know but little of his life. He, however, was educated in Alexandria, and practised in that city with very great success. He was also a famous writer, but of all his works—and they must have been numerous—the only one preserved until our day is the great compendium of medicine in seven books, called "*Hypomnema.*" This book became at once a high authority, and so remained not merely throughout the Byzantine middle ages, but also through the whole of the saracenic period.[1] Even at the present day it possesses a remarkable interest, for the sponge-like Paulus, having, as it seems, the freest access to that great repository of ancient learning the Alexandrian library, and at a time just prior to its destruction by the Arabs, absorbed the medical and surgical learning of the age and gave it forth again to later generations in the form of his all-embracing work, "*Hypomnema,*" truly a monument both to his own industry and to the medical and surgical attainments of the Greco-Roman world.

The parts of the great treatise that deal with ophthalmology are: Book I, Section 31, "On Dimness of Sight"; Book III, Section 22, "On Diseases of the Eye"; Book VI (Surgical), Section 2 "On Burning of the Head for Ophthalmia," and Sections 4 to 22 inclusive, which treat of nearly all the other surgery of the eye as this was known and practised in the seventh century A. D.

All these parts now follow in the order above-mentioned:[2]

Book I, Section 21. ON DIMNESS OF SIGHT.

In order to avoid dimness of sight when they plunge into cold water people ought to open their eyes wide, for thereby the strength of their eyes will be much improved. They ought also to be careful not to hurt them by reading. Let them also avoid wine that is thick and sweet, such articles of food as ascend upwards, whatever is of difficult digestion, and engenders crude and thick humors, the herb

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[1] The Saracens called the *Hypomnema* "The Collection of the Pleiades," in allusion, of course, to the seven books of which it is composed, and to their brilliant and permanent character.

[2] The original text of Paulus being absolutely inaccessible to me, I have given without change the English translation of Adams published by the Sydenham Society at London in 1844-48.

rocket, leeks, and everything whose pungency ascends upwards. Let them also avoid reclining long in a supine position, cold, winds blowing direct in the face, smoke and dust; and pour daily into the eyes an infusion prepared thus: for a month and a day, put green fennels into an earthen vessel smeared with pitch on the outside, and pour in rain water, and then taking out the fennels, keep the water laid up for use.

Book III, Section 22. ON DISEASES OF THE EYE; AND FIRST OF PAIN, FROM GALEN.

When violent pains in the eyes take place, consider from what diathesis the eye happens to be pained in the inflammations; for they are either occasioned by the pungency of an acrid defluxion, or from the coats being over-filled and stretched, or from the distension of thick humors or of flatulent spirits. When the pains proceed from pungency, they are to be cured by evacuating with purgatives, and by injecting into the eye the white of an egg. When the inflammation is concocted, if the body be free of impurities, the most befitting remedies are baths. Inflammations from plethora are to be cured by the detraction of blood, purging the belly, and applying friction to the inferior extremities. Those from distension are to be cured by first evacuating the whole body, then by occasioning a revulsion downwards of the humors, and afterwards by using topical applications of a discutient nature. The eyes must be fomented, and the decoction of fenugreek poured into them. When the vessels of the eye are distended with thick blood, while there is no plethoric diathesis in the general system, the patient must drink wine which has the power of heating, evacuating, and removing obstructions.

On disorder of the eye, and particularly of ophthalmy. Disorder of the eye is a wateriness and heat of it, with preternatural redness, not occasioned by any cause within the body, but by some external one, such as the sun, smoke, dust, or the wind; wherefore it is soon dispelled when the cause is removed. And ophthalmy is a marked disorder which may be occasioned not only by an external cause, but also without any obvious one, and remains until the third, fourth, or fifth day. It is best cured by avoiding every external exciting cause, by spare diet, drinking water, walking, and by opening the belly.

On inflammation. When inflammation remains in the eyes after evacuation of the general system, we may use ointments for dispelling the rheum, and soothing the irritation, such as the collyrium of Nilus made from roses, the chiac, or the collyrium from nard. When the

tunica adnata is inflamed, we may use the collyria called monhemera, injecting them into the eye with the white of an egg. Next day, if the inflammation be not aggravated, we may anoint them with the collyrium of nard, and use a fomentation of the decoction of melilot and fenugreek. When the humor which occasions the ophthalmy is thick, we may use medicines which are neither obstruents nor incrassants, but which, on the contrary, will dissipate, dilute, and evacuate the humors, such as the chiac collyrium. But, if the humors are impacted in the head, we may fix a cupping instrument to the hind head, or scarify, or apply leeches to the forehead, near the eye affected. We must use cataplasms of pure bread soaked in water, with a little rose-oil, or polenta boiled in the decoction of poppy-heads also with rose-oil. We may also use a more efficacious cataplasm from saffron, melilot, the fleshy parts of dates, the tender leaves of coriander, eggs, and roasted wheat and crumbs of bread dipped in a decoction with a small quantity of rose oil, in a decoction of pounded poppy heads. We mix also the seed of the poppy as an anodyne. If compelled by the severity of the pain, we must add a little opium; but, unless the pain be very violent, we must abstain from all narcotics. If the inflammation be moderate, apply aloes by itself, or rub it in with water or the white of an egg. In order that the remedy may be ready for use, take of saffron, dr. vj; of aloes, dr. xvj; of gum, dr. ix; mix with rain water, and make a collyrium. And the saffron collyria, as they are called, are proper for the commencement of ophthalmies. In those cases in which there is an edematous and white swelling about the eyebrows and tunica adnata, without injury of the coats, the best applications are those called liquid collyria, prepared from saffron, copperas, and honey. And this one is excellent:

A liquid anodyne collyrium. Of the melanteria used by tanners, of Attic honey, of the juice of fenugreek, equal parts. Boil to the thickness of honey, and touch the two angles of the eye with it, by means of the rounded extremity of a specillum or probe.

For a copius defluxion. For a flow of humors, in the commencement abstinence from food is proper, and the drinking of water, and most especially abstinence from venery; the belly should be opened, and the face washed with a watery oxycrate, if the rheum be of a hot nature, but if otherwise, the forehead and eyebrows may be anointed with copperas and honey. Some dissolve the copperas in water, and bathe with it. In defluxions without inflammation, or with inflammation, but so that the affection is seated above the skull, we must use agglutinative applications to the forehead, either simple ones, such as green vine leaves, or the juice of the bramble, or of purslain, or of

quinces with some fine polenta, or with gall levigated in wine, or with fine polenta or hemlock, or flea-wort with water, or nightshade, or snails with their shells pulverized and applied from temple to temple, and, in a word, with things of an astringent and cooling nature, or with the following compound applications: wheat flour, and myrrh or frankincense, with the white of an egg, may be rubbed in; or Samian earth, with myrrh and manna, in like manner, with the white of an egg; but in colder defluxions, of native sulphur, of bitumen, of pitch, of coloponian rosin, of each, dr. ij; also the trochisk of Musa, that called aster, and the like, are suitable repelants. And the theriac, dissolved in an astringent wine, and rubbed on the forehead, stops cold defluxions, and may be drunk with great advantage. Over the eye apply wool, or a small rag wet in the white of an egg; and new made cheese, in like manner, when applied to the eye, restrains acrid defluxions in particular; also the astringent collyria, as they are called, when rubbed in or injected into the eye in a watery state, do the same thing. But if the humor be deep-seated, and below the skull, and if fixed there for a length of time, after the general evacuations use errhines and masticatories, shaving the head, and applying rubefacients to it. But to these must be joined the surgical operations for the head, namely, Angilogy, Arteriotomy, Hypospathismus, and Periscyphismus, with burning at the vertex down to the bone. But cupping instruments, with scarifications applied to the hind-head, will produce a revulsion of the defluxion. The symptoms of defluxions external to the skull are distension of the vessels of the forehead and temples, forming, as it were, a band to the head, and the complaint being remedied by agglutinative applications of a desiccant nature. When these symptoms are not present, and the defluxion proves of long duration, and sometimes is exasperated by sternutatories, the humor is to be supposed seated below the skull.

On chemosis. The disease is called chemosis when both the eyelids are everted in consequence of a violent inflammation, so that the eyes are scarcely covered by them, and the white of the eye is elevated above the black, is red, and occupies a large portion of the black. We must cure it by phlebotomy, purging, the white collyrium of roses, and the spodiac, with milk, or the white of an egg, and we may annoint the eyelids, temples, and forehead with the same, and have recourse to paregoric fomentations and cataplasms. When the inflammation begins to remit, we may rub in the more acrid applications, such as the green one from roses.

On hyposphagma and emphysema. Hyposphagma is a rupture of the veins of the tunica adnata, occasioned most frequently by a blow.

Bathe the eyes with the blood of the wood-pigeon, or of the common pigeon, or the warm milk of a woman in which a little frankincense has been triturated, and inject brine, more particularly that from Cappadocian salts, and use a fomentation from the decoction of hyssop. Swellings about the eyes from blows are remedied by repeated fomentations with oxycrate, or a sponge out of oxycrate may be applied to them, or a liniment may be used, consisting of equal parts of burnt lapis specularis, and pigeon's dung, triturated with wine or vinegar. Or a cataplasm may be applied of new cheese, or of the rind of radishes, or of dried grapes without the stones. Each of these is to be mixed with oxycrate or honied water. The same remedies apply also to emphysema.

On prurient emphysema and psorophthalmia. Emphysema is an edematous swelling of the eyelids; but psorophthalmia is a scabious eruption of the eyelids attended from pruritis, arising from a saltish and nitrous humor. They are remedied by oxycrate, the decoction of lentils, and fomentation of roses. The following is a liquid collyrium: Of copper, dr. vj; of calcined misy, and myrrh, of each, dr. iij; of saffron, dr. iss; of pepper, dr. j; of Chian wine, and Cretan sweet wine, of each 1½ cyathus; boil to the thickness of honey. This is the collyrium of Erasistratus called panchrestos, which applies to cynanche, ulcers in the mouth, and on the privy parts, and to the earache. They are to be rubbed with oil into the patient's eyebrows when he is going to sleep. Acid, saltish, and acrid things are to be abstained from.

On sclerophthalmia and xerophthalmia. Sclerophthalmia is a hardness of the eye with difficulty of motion, pain, and redness, without wateriness. For this the eyes are to be fomented frequently with sponges out of hot water; and at bedtime the white of an egg with rose-oil, or the fat of geese, may be applied to the eyelids. Let them avoid everything of a cooling and hardening nature; let the head be covered and anointed, and the belly kept open. Xerophthalmia is a pruriginous affection of the eyes without rheum. It is to be cured by baths, unguents, and a wholesome diet. Applications of an acrid nature are suitable to both, as they promote a flow of tears, by which the hardness will be softened, and the dryness rendered more humid. Such are the panchrestos of Erasistratus, and those called dicenteton and stratioticum.

On ectropion, or eversion of the eyelids. This complaint is an eversion of the eyelids, occasioned either by a scar or fungous flesh. When it is occasioned by fungous flesh, and is of long duration, roast scraped verdigris, pulverize it and apply, or use burned lead washed with sul-

phur vivum, or apply both in equal parts, namely, the verdigris and the lead. Ectropion from a cicatrix, if at all remediable, must be cured by a surgical operation.

On ægilops and anchilops. Ægilops is an aposteme between the great canthus of the eye and the nose, which breaking and being neglected, ends in a fistula that extends to the bone. Before the aposteme breaks out into an ulcer, it is called anchilops. A very good application is horned poppy and saffron, applied with the juice of perdicias (*pellitory of the wall?*) They must be frequently changed, and till then it will not turn to pus.—*Another*: Alica, boiled in vinegar and properly triturated, not only cures the disease at the commencement, but, after suppuration, it bursts the abscess and penetrates to the bone. By using it, you may cure not only ægilops but anchilops.—*Another*: Garden rue, levigated and boiled with protostactos and applied, answers excellently for ægilops, penetrates to the bone, proving stimulating at first, but afterwards not so; and, what is wonderful, it does not leave an ugly scar.—*Another*: Pulverize snails with their shells and apply them; and sometimes aloes or myrrh may be added before the ægilops is converted to pus; and after the abscess bursts it dries up the pus.

On trachoma. Trachoma is a roughness of the inner surface of the eyelid, an intense degree of which has the appearance of clefts, and is called sycosis. When it becomes chronic and callous, it is called tylosis. We must use collyria for it, namely, the one from wine, and that prepared from the two stones; or the eyelid may be rubbed with the bloodstone itself (hematites,) much washed in water. But the collyrium called harmation, with a little of the cycnarius, or the saffron collyrium, answer well with these, and with cases of psorophthalmia without ulceration, when rubbed upon the everted eyelid. But if the callus be hard and do not yield to these things, we must turn the eyelid out and rub it down with pumice stone, or the shell of the cuttle-fish, or fig leaves, or by the surgical instrument called blepharoxyston.

On chalazion. Chalazion is a concretion of an indolent humor in the eyelid, for which pound ammoniac with vinegar, and anoint along with galbanum. It likewise has a good effect when joined with cerate and turpentine.

On hordeolum, or stye. Hordeolum is a small oblong aposteme on the tarsus of the eyelid. We may foment it with white wax, or throwing away the head of a fly, we may rub the part with the rest of its body; or wash with the decoction of barley.

For lice in the eyebrows. Having first cleared away the podiculi, wash the part with tepid sea-water, and use the under-mentioned appli-

cation to the tarus: Of fissile alum, two parts; of stavesacre, one part; triturate, and use.

On madarosis, or milphosis. This affection is a falling off of the hairs of the eyelids. Wherefore, after attending to the general health, use the detergent ointments called calliblephara. Of cannel-coal, of Celtic saffron, of laudanum, equal parts; pulverize, and use.—*Another*: Of antimony, calcined and cleaned, dr. j; of lead, burned and cleaned, dr. iv; of saffron, dr. iv; of Indian nard, dr. iij; pulverize, and use.—*Another*: Of the burnt bones of dates, dr. iij; of Celtic nard, dr. ij; pulverize, and use. This also cures scabious eyes.

That of Neopolites for milphosis and chronic affections of the eyelids. Of antimony, of cadimia, of chalcitis, of foreign misy, of each, equal parts; beat together coarsely, mix with honey; when roasted, triturate, and use.

On ptillosis. Ptillosis is a callous thickening of the eyelids, of a red color, and often accompanied with a falling out of the hair. In addition to those already mentioned, the following is an excellent application: Rub with mice dung burnt, and triturated in honey.

For a falling off of the hairs of the eyebrows. Anointing the fingers with oil, or geese fat, rub them upon lead, and anoint with this.—*Another*, which also darkens the hairs: Triturate burnt Pontic walnuts with the fat of goats or of bears.—*Another*, which also applies to alopecia of the chin: Of henbane, dr. ij; of mice dung, dr. j; of maiden-hair, dr. j; of the oitment of iris, four spoonfuls. Pound well together, mix the ointment, and, having first fomented, anoint. If you previously shave the part, it will be more efficacious.

For trichiasis of the eyelids. Having first torn out the hairs which irritate the eye, anoint the part immediately with the blood of a frog by itself, or with the ashes of white chameleon, or the blood of bugs; or the juice of the fumitory, which grows among barley, mixing it with gum, or the ashes of pickled limpets with cedar rosin (*gum vernix?*), or the ashes of the lotos; or liquid alum, called *phorimum;* or the blood of a tick taken from a dog. It is very efficacious.

Agglutinative medicines. The following substances agglutinate the hairs when bent inwards: Bitumen, mastich, colophonian rosin, glue, the glutinous part of snails.

On encanthis and rhyas. Encanthis is an excrescence of the natural flesh at the great canthus, but rhyas is a wasting of it. You may treat encanthis with the remedies mentioned for ectropion, and similar caustic, or septic applications; but the whole substance must not be consumed, lest rhyas be produced, for it must only be reduced to its natural size. Rhyas, when the whole flesh is consumed, either by an

awkward surgical operation or medicines, is incurable. But if part of it only be lost, you may restore it by moderately astringent and incarnating applications, such as that from saffron, horned poppy, and aloes; and the saffron collyria, and henbane boiled in wine and applied, and a small quantity of alum with wine.

On ulcers. Of the ulcers in the eyes there is but one genus, but many particular species. For that in the cornea, when hollow, narrow, and clean, is called bothrion. That which is broader than the bothrion, but less deep, is called coeloma. Argemon is the name given to that which arises on the circle of the iris, but affects the surrounding parts, so that the part which is on the external side of the iris is red, but that on the internal white. Epicauma is a foul and impure ulcer with eschars, which when cleaned away, often give vent to the humors of the eye. There are many other varieties of ulcers, all of which we shall treat of in general terms. If, therefore, the ulcer happen to be attended with inflammation, the cure must be accomplished by such things as are calculated to soothe and digest the inflammation, regard being had to the peculiar nature of the ulcer. Such are the collyria, called *libanium, cycnos,* and *palaria, aster,* and the like and those from starch, Samian earth, and ceruse. But the most sedative collyrium which we are acquainted with is that of Nilamon; and yet we must not persevere long with it, because it very narcotic. The best of all applications is the collyrium from decoctions not possessed of a narcotic quality. But if the ulcer be attended with a rheum, we must mix some of the collyria for it, such as that from the *hydra,* the *chiac,* the yellow *cycnos,* and such as possess repellent properties without being stimulant. When the ulcers are foul, we must use honied water moderately diluted, and the decoction of fenugreek, by themselves, and along with the collyria for that purpose; when they are acrid, we may use that of Severianus with the diachylon from fenugreek; when not acrid, those from myrrh and nard. When the ulcers are cleaned, they may be cicatrized by means of the collyrium called *cleon,* in addition to which it will render the scar of the same color.

On procidentia. Procidentia is a projection of the coat called uva (*iris?*), formed by an ulceration and rupture of the cornea. When, therefore, it is small, so as to resemble the head of a fly, it is called myocephalon. When it increases more, so as to resemble a grape-stone, it is called staphyloma; when it advances far forward, so as to protrude between the eyelids, it is called melon; and if it has become callous, it is called clavus. If, therefore, the projection is small, like the head of a fly, we must use repellent and astringent applications, such as the chian, that called *fuscum,* the *nard,* and the *theodotian,*

and those from olive leaves, and from horn. And we must bind upon them without pressure a piece of sponge which has been soaked in oxycrate, or astringent wine, or the decoction of roses, or the compress called splendium may be used. The best application for procidentia, and all ulcers of the eye, is the collyrium called *olympiac* or *olympus*, with the juice of olive, or of knot-grass, or of poley. The same things are applicable to clavus and staphyloma, before they whiten; for after they become white and callous, they are incurable.

On hypopyon. Hypopyon occurs occasionally in the cornea, being sometimes deeply seated, and sometimes more superficially, the matter assuming the shape of a nail, and hence the affection has got the name of onyx. The indication of cure is either to dispel the pus by remedies possessing this property in a moderate degree, such as honied-water, and the juice of fenugreek, and the collyria formed from it, the libyanum, and those from frankincense; or to make it burst, and cleanse the ulcer by means of the more potent remedies, such as those called *diasmyrna* and the *hygidian*. For cases of hypopyon without ulceration one may use the following liquid collyrium: Of copperas, and of saffron, of each, dr. viij; of myrrh, dr. iv; of honey, lb. j. The phlyctena, which is an elevation of the cornea, by a certain humor corroding its fibres, yields to the same treatment as hypopyon.

The liquid collyria of Bassus for hypopyon. Of saffron, of aloes, and of myrrh, of each, oz. j; of wine, oz. iij; of the finest honey, oz. vj. The saffron is to be levigated with a small quantity of the wine, then with the aloes and myrrh; and when it thickens, add the honey, and having mixed together, lay up in a glass vessel, and use twice a day, or, if the case be urgent, three times. It at the same time cleanses the eye and proves incarnating and cicatrizing.

On cicatrices and leucomata. Superficial scars on the eye are called by some cicatrices, and by others nebulæ; but the more deeply seated are called leucomata. The proper remedies for them are those of a detergent and cleansing nature. Wherefore, nebulæ may be cleansed by the juice of anemone, and that of the small centaury, with honey; but the more chronic are reduced by cedar gum, or by copper alone levigated with water for a collyrium, and by the cleansing collyria, such as that from hartshorn, and those called *rhinarian*, *hecatombe*, and the like. Leucomata may be cleared away by nitre carefully levigated with some old oil, and properly smeared upon them, and by the shell of the cuttle-fish (*sepia*) burnt and pounded finely with honey. Among the collyria, the following one proves an excellent and mild detergent: Of mamira, of ammoniac perfume, of troglodytic myrrh, of crocodile's dung, equal parts; make a collyrium, and use.

Levigate the dung of the land crocodile with water, and anoint, having formed it into a collyrium. You may also succeed well by dissolving Cappadocian salts in water, and then dissolving the collyria for leucoma in it, and injecting it.

Dyes for cicatrices. Of galls and acacia, of each dr. iv; of copperas, dr. ij; use. The following is a collyrium: Of the flowers of the pomegranate, of copperas, of acacia, of gum, of each dr. iv; of antimony and galls, of each dr. ij; triturate with water. When the flowers of the pomegranate are not at hand, you may use the internal membrane between the seeds.

On pterygium. Pterygium is a nervous (membranous?) excrescence of the tunica adnata, arising at the angle of the eye, and advancing to the corona. When it increases greatly, it covers the pupil itself. Wherefore, large and chronic pterygia can only be extirpated by a surgical operation. But the smaller and more recent ones may be worn down by the abstorgent applications, such as those used for trachoma and leucoma. Among the simple remedies are burnt copper, and copperas with the gall of swine, which answer well. The following is a more potent remedy: Of copperas, p. i, of gum, p. ss.; triturate with wine, and anoint, or form into collyria. Some mix the gall of a goat with honey, and anoint with it.

For pterygium, hypopyon, and dimness of vision. (From Oribasius.) Of the magnet-stone, of scraped verdigris (xyston), of reddle, of ammoniac perfume, of each dr. iv; of saffron, dr, ij; of Attic honey half a spoonful. It also answers for leucoma.

For carbuncle and carcinoma. Carcinoma is an affection of the cornea, attended with pain, distension, redness of the tunics, and pungent agony, extending to the temples, more particularly if shaken. They loathe their food, and have the pain increased by acrid things. The affection is incurable, but may be alleviated by a milk diet, farinaceous and otherwise wholesome food, devoid of all acrimony; and the injection of soothing collyria, such as the Spodiac, Severianum, and the like. We must previously attend that the general system be in a proper temperament. Carbuncle also is a malignant ulcer of the sloughy kind, forming sometimes in the ball of the eye, sometimes in the eyelid, as in the other parts of the body. In cases of carbuncle of the ball of the eye, we must first evacuate with a clyster, and then purge moderately with boiled milk, afterwards foment with a sponge, and apply a cataplasm of the flour of tares, or of wheat boiled in honied water, or sometimes we may add pounded iris, and wash the eye with milk. If the ulcer spread, we may apply a cataplasm of lentils with honey or boiled quinces: if it continue spreading, we may use the boiled leaves of the

olive, the rind of the pomegranate boiled in wine and pounded with honey. When the ulceration stops, and the eschar falls off by the application of the medicine about to be described, and the ulcers have become clean, we may apply a cataplasm of the roasted yolks of eggs, triturated with saffron and honey, until the ulcer is healed. The medicine is this: Of spodium, dr. iv; of myrrh not much toasted, dr. iij, and oboli iij; triturate in Aminaean wine until it becomes dry, mix old Cretan sweet wine, and having triturated, lay up the liquid in an earthen vessel, and anoint with it. For carbuncles of the eyelids, having cut an acid pomegranate, boil it whole in vinegar, and, when softened, pound it into a linen cloth, and use. Change twice or thrice during the day, and once during the night.

On mydriasis. When the pupil does not appear changed in color, but much wider than natural, and when it sometimes wholly impairs the vision, and sometimes nearly so, and when every object appears smaller, the affection is called mydriasis. The cause of it is some redundant humor. We must cure it by bleeding from the arm, or purging; but, if not, by dividing the veins in the angles of the eye, and then applying a cupping instrument to the back part of the head, and bathing the face and eyes with sea-water, or, if it be not at hand, with brine or oxycrate. We must also use the remedies which are applicable to phlyctenæ or blisters.

On phthisis and atrophy. Phthisis is an affection of the pupil, which is contracted, and appears duller and more rugose than usual, but objects seem larger than natural. The cause of it is condensation, mostly occasioned by dryness. Phthisis differs from atrophy in this, that phthisis renders the pupil contracted, whereas in atrophy the whole eye is smaller and more depressed. We may cure them by exercise, and rubbing carefully the head, the face, and the eyes; by bathing the face with water, and anointing the head with some healing ointment; and smearing the eyes with an attenuant and acrid composition, such as the following: Of ammoniac, dr. j; of crocomagma, dr. iv; of saffron, dr. ij; of verdigris, dr. j. Triturate in water, form and use.

For nyctalopia. In the disease called nyctalopia, the patient sees during the day, but at sunset his vision becomes dimmer, and when night comes on he does not see at all. We must effect the cure by bleeding from the arm and the angle of the eye, then purging or evacuating by a clyster, and afterwards ordering masticatories or sternutatories. Before food, we give hyssop to drink, or rue; but, if the disease do not yield, we must again administer the purgative medicine formed from scammony, and castor, anoint with a clarified honey, and

make the patient shut his eyelids, so as to retain the liquid application. Or, of burnt alum, p. ij; of fossile salt, p. j; triturate with honey and anoint.—Another: Having roasted the liver of a goat, collect the ichor during the roasting and anoint, but give the liver itself to eat; or boil, and direct the vapors to be received with open eyes.

For glaucoma and suffusion. (From Ruffus.) The ancients considered glaucoma and suffusion as the same disease; but by their successors glaucoma has been accounted an affection of the crystalline humor, which is changed by a watery substance to a cerulean color; but suffusion is reckoned a defluxion of humors concreted between the cornea and the crystalline lens. Glaucoma is in every case incurable. Suffusion may indeed be cured, but not always. We may try to cure suffusion before the disease is completely formed, by taking blood from the arm, by purging and acrid clysters, such as those made from the decoction of centaury, or of the bitter cucumber, and by keeping the bowels for some time in a loose state. Cupping instruments with scarifications may be applied to the hind-head; the patient must drink water during the whole regimen, take attenuant food, and, in process of time, masticatories may be used for a few days with advantage. When the vision is depraved, as, for example, gnats appearing before the eyes, which case proceeds from a cacochymy or from bilious vapors ascending to the head, we may give for a time the bitter medicine from aloes, or purge with it. To the eyes we must make applications at first simple, such as honey and oil, with the juice of fennel, and afterwards compound, such as this: Of sagapene, dr. ij; of Cyrenaic juice, of white hellebore, of each, dr. vj; triturate with eight heminæ of honey. We, says Oribasius, use the following medicines: Of the juice of wild carrots, of germander, of cresses, of each equal parts; triturate. The following collyria are beneficial, namely, that from the juice of the fennel, that called *proteus*, the *thalasseros* and that from opobalsam. The collyria prepared from them are useful, and the decoction of fennel in the commencement answers well as a fomentation, and that from juices, opobalsam, honey, old oil, and the like.

On amaurosis and dimness of sight. Amaurosis is, for the most part, a complete impediment of the sight without any apparent affection about the eye; and dimness of sight is an imperfection of vision arising without any sensible cause. The same mode of cure as that described for suffusion applies generally in this case; but, in particular, blood may be abstracted from the corners of the eye, leeches applied to the temples, and friction of the extremities. In process of time we must have recourse to sternutatories, emetics with an empty stomach, and the application of ointments, at first with equal parts of honey and

oil, and afterwards with the under-mentioned composition: Of saffron, two oboli; of the gall of the hyena, dr. j; of common pepper, eighty-five grains; of fennel juice, dr. xvj; of ammoniac perfume, dr. j. Triturate the dry substances with the juice, add four spoonfuls of honey, prepare and lay up in a copper vessel for use. Before using, let him foment the eye by immersing them in hot sea-water.

On strabismus, or squinting. Congenital squinting is cured by the application of a mask, so that the children are compelled to look straight forwards; for strabismus is a spasmodic affection of the muscles which move the ball of the eye. And the lamp should be placed fairly opposite, and not so as to shine obliquely. When the eye is turned to the nose, purple flocks of wool should be fastened to the outer angle of the eye, so that by looking steadily at them, the persons affected may correct the state of the eyes.

On ecpiesmus. The eyes are sometimes forced out, so as to remain prominent. When this happens from strangulation, we must let blood from the arm; but if otherwise, we must purge with black hellebore or scammony. When the eyes become prominent from the pain of labor, the complaint is often removed by the cleansing after parturition; hence we ought to promote it; and, in men, after phlebotomy, if it do not abate, we may affix a cupping instrument to the back part of the head, and apply wool smeared with honey, or flocks of it with water, and bind a compress gently above it. Cold salt water poured upon the face is likewise suitable to them, and also the juice of the endive and knot-grass, rubbed in with the juice of poppy, and whatever else can repress and contract.

On synchysis, or confusion. Confusion of the sight occasioned by a blow may be cured by bleeding from the arm, and by filling the whole eye with the blood of a newly-slaughtered animal, of a turtle in particular, but, if not, of a pigeon, and then applying soft wool which has been immersed in an egg beaten up with wine and rose-oil, and binding it on the place. The same thing is to be done next day; and on the third, it is to be fomented, washed with milk, and suitable cataplasms applied; after which it is to be anointed with the remedies for old affections, such as Chiac.

For myopia. Those persons are called myopes, or near-sighted, who, from their births, see near objects, but not those at a distance. Such a state is wholly incurable, being occasioned by a weakness of the optic spirit. Old men are affected in the opposite manner to these, for they do not perceive near objects, but see those at a distance.

Book VI, Section 2. ON BURNING OF THE HEAD FOR OPHTHALMIA, DYSPNEA, AND ELEPHANTIASIS.

In ophthalmia, occasioned by a defluxion from above, and in dyspnea, produced by a redundance of a recrementitious humor which is sent from the head down to the chest, and by lodging there proves injurious to the parts contained in it, they burn the middle of the head in this manner. Having first shaven the parts about the vertex, they apply cauteries shaped like olive-kernels and burn the skin down to the bone, scraping the bone after the falling off of the eschar. Some by burning even the bone itself make a small scale exfoliate from it, in order to allow the humors of the head to perspire and be evacuated the more readily; and for this purpose they keep the ulcer open for some time and then allow it to cicatrize. In treating elephantiasis some burn five eschars in the head, one anteriorly above the part called the bregma; another, below this, a little above the forehead, at the extremity of the hairs; another, at the part called the occiput; two others at the parts called the squamous plates, above the ears, one on the right side and another on the left; and thus, by the removal of several scales, they procure the evaporation and discharge of the collection of thick humors in the deep-seated parts of the head, and prevent the sight from being injured. They also apply another cautery on the spleen, in order to remedy the prime organ in the formation of the melancholic humor by the eschar formed in the skin.

Book VI, Section 4. ON ARTERIOTOMY.

In chronic defluxions of the eyes, and in the affection of vertigo, we are in the practice of dividing the arteries behind the ears. Having, therefore, shaven the hind part of the head, and marked with the fingers the position of the artery, which is easily discovered by its pulsation, and then having marked out the line of an incision two fingers in length with black ink, we cut down to the bone. When this does not succeed we must measure a distance of three fingers' breadth from the ears, and then operate by making a transverse division of the artery until blood flow *per saltum*, and the instrument strike the bone. After a moderate evacuation of blood, the pericranium is to be divided, lest it become inflamed from the distension; and having scraped the bone we apply a wedge-like tent of linen to the wounds, and accomplish the cure by pledgets. But if, after all, the bone remain bare, we must have recourse to scraping it in like manner.

Book VI, Section 5. ON ANGIOLOGY, OR SECTION OF THE TEMPORAL VESSELS, AND ON BURNING THE SAME.

In hemicrania and in chronic or acute defluxions, when the eyes are affected with a hot and acrid defluxion, so as to occasion heat of the temporal muscles with swelling, every one approves of angiology for the cure of them. Having, therefore, first shaven the hairs of the temples, and noted the part with our fingers, we must use warm fomentations, and apply a bandage round the neck; and, when the vessels become visible, having marked their course with ink, we must draw the skin aside with our left hand or the fingers of an assistant, and make a superficial incision along the vessel; then cutting quite through, and stretching the parts with hooks, and exposing the vessel by means of the instruments used in operations on membranous parts, we must raise it up when it is separated all around. If it be small, having stretched and twisted it with a blind hook, we may divide it through, so as to be able to seize upon part of it. But if it be large, we must apply a double ligature under it with a needle, either a piece of raw flax, or some other strong thing; and, in the first place, making a straight opening into the vessel with a scalpel used in venesection, and taking away a moderate quantity of blood, we must tie the ligatures at both extremities of the exposed vessel, and cutting the intermediate part, we may remove it either immediately, or at the time of loosing the dressings. Some, without dividing the vessels at all, burn them to a sufficient depth with burning-irons shaped like olive-kernels. After the operation we must use pledgets of dry charpie, and put on an oblong compress (*splenium*) with a bandage. After the removal of these dressings, we must accomplish the cure by incarnating powders, applications on pledgets, and cicatrizing remedies; the threads and ligatures having previously dropped out from putrefaction.

Book VI, Section 6. ON HYPOSPATHISMUS.

This surgical operation derived its name from the kind of instrument used in it. We have recourse to it when a copious and hot defluxion is determined to the eyes. The face is ruddy, and about the forehead there is a sensation as of worms or ants passing along it. Having therefore first shaven the hairs about the forehead, we must permit the lower jaw to move, and avoiding the place where the temporal muscles are seen to act, we are to make three straight and parallel incisions on the forehead, each having the length of two fingers, and descending to the bone, and being at the distance of about three fingers breadth from one another. After the incision we apply the instrument

called hypospathister, and extend the division from the left temple to the middle incision, dividing all the intermediate substance along with the pericranium; then we push a spatula from the middle one to the rest, and applying the point of a sharp-pointed knife to the first division, so that its sharp side may be turned to the flesh within the skin, and the blunt one to the bone, we push it as far as the middle division, cutting through all the vessels which descend from the head to the eyes, but not comprehending the external skin. And again we push it from the middle to the last incision, cutting through the vessels in like manner. After a moderate evacuation of blood, having squeezed out the coagula, and made three twisted tents, we are to put one into each division, and applying a compress soaked in water, we must secure it with a bandage. Next day we bathe not only the ulcers, but likewise the temporal muscles, and the ears with wine and oil, on account of the inflammation; and on the third day having removed the dressings, we must have recourse to copious affusion, and afterwards complete the cure suitably with tents out of basilicon dissolved in rose-oil.

Book VI, Section 7. ON PERISCYPHISMUS.

When many deep-seated vessels send a copious defluxion to the eyes, we have recourse to the operation called periscyphismus. These cases are attended with such symptoms as these: in the first place you will find the patient's eyes atrophied and small, weak of sight, the canthi corroded, and the eyelids ulcerated, the hairs falling off, with a discharge of very thin, acrid, and hot tears; there is a deep-seated pain in the head of an acute and violent character, and there is frequent sneezing. Having first shaved the head as aforesaid, and avoiding the place where the temporal muscles play, we make a transverse incision, beginning at the left temple and ending at the other. The incision must have its terminations where there are no muscles, its direction being a little above the forehead, and we must avoid the coronal suture. Leonidas directs the incision to be made along the middle of the forehead. When the bone is laid bare we may keep the parts asunder with tents and plenty of pledgets, and bind the extremities of the division; and, as we formerly stated, bathe with wine and oil. After loosing them, if the inflammation is on the decline, we may scrape the bone until it begins to incarnate, and accomplish the cure by a mode of practice calculated to promote incarnation, using the incarnative powders; among which is that containing of wheaten flour, p. ij; of colophonian rosin, p. j; and that called the cephalic, and those incarnatives prepared from pumice-stone. For, when the skin is thickened

by a dense cicatrix, and the mouths of the vessels constricted, the defluxion is prevented from being determined to the eyes as before.

Book VI, Section 8. ON SUTURE OF THE UPPER EYELID, AND OTHER MODES OF OPERATING FOR TRICHIASIS.

Distichiasis is a preternatural growth of hairs, superadded to the natural order of hairs of the eyelids; and derives its origin from a defluxion, when there happens to be a flow upon the part of a humor which is not pungent or acrid; for that which is more acrid, saltish, or otherwise pungent, when it lodges in these parts, consumes the natural series of hairs. For this state then we sometimes have recourse to the suture of the upper eyelid, and sometimes also for phalangosis when the eyelid inclines inward, the phalanx or row of the hairs being inverted; and sometimes for relaxation of the eyelid, when the natural row of hairs hurts the ball of the eye. Having placed the patient on a seat, either before us or on the left hand, we turn the upper eyelid outwards, and if it has long hairs, we take hold of them between the index-finger and thumb of the left hand; but if they are very short we push a needle having a thread, through the middle of the tarsus from within outwards; then stretching the eyelid with the left hand by means of this thread, with the point of a scalpel held in the right hand, having folded out the eyelid and everted it, behind the thread we make the under-incision within the hairs which irritate the eye, extending from the larger canthus to the smaller, along the tarsus. After this subsection, having extracted the thread, and putting a small compress under the thumb of the left hand, we stretch the eyebrow upwards. Then arranging other small compresses on the canthi at the extremities, we direct the assistant who stands behind to stretch the eyelid by means of them. Then by means of the scalpel used for sutures we make the first incision, called the veruted (shaped like a verutum or short dart) a little above the hairs, which are in their natural state, extending from canthus to canthus, and penetrating only the depth of the skin; and afterwards we perform the incision called the lunated, beginning at the same place as the former, and carrying it upwards to such a height as to comprehend the whole redundant skin, and ending in like manner as it did. Thus the whole skin comprehended within the incisions will have the shape of a myrtle leaf, of which portion, having perforated the angle on the right hand with a hook (tenaculum), we dissect away the whole skin: then washing away the clots with a sponge, we unite the lips of the incision by three or four sutures, beginning at the middle, and passing the needle itself through the under-section. The thread should be made of wool; and having cut away

the superfluity of the thread, not close to the sutures, but so as to leave a superfluity of three fingers' breadth, we stretch this remainder along the forehead and fasten it by means of any of the agglutinative plasters. But the hairs of the eyelid are to be freed from the sutures with the point of a needle. Such is the common and safe mode of performing this surgical operation. Some avoid the dissection of the skin, and therefore after the under-incision, having stretched the redundant skin by means of the forceps used in operations on the eyelids, they cut it off with a scalpel, and apply sutures as described above. But if the irritation from the hairs is produced only by a part of the eyelid, it will be proper to confine the operation to that part. Then soaking the compresses in oxycrate, and laying them on the part, we secure them with bandages, continuing to moisten the dressings with diluted oxycrate until the third day; after which we remove them, and cutting away the superfluous parts of the threads, we anoint the eyelids either with saffron, glaucium, or some of the anti-inflammatory collyria, such as that formed of saffron and roses. But if the sutures inflame, we apply some of the softening plasters, and soothe the eye by an injection of eggs mixed with milk. When the ligatures slacken we cut and extract them. I know of a certain person who having made the dissection of the skin of the eyelid, as mentioned above, did not have recourse to sutures, but effected the cure with a healing ointment. For when the wound cicatrized, the eyelid being somewhat contracted, forced the hairs to incline outwards. In like manner, another person not practising the dissection of the eyelid, nor the two external incisions, but only making the under-incision, stretched with his fingers or by a hook the fold of the eyelid, two reeds or plates of the same length as the eyelid, and as broad as for venesection, he twisted a ligature round it at both its extremities; and thus the whole skin behind not being nourished, and on that account being deprived of life, fell off within ten, or at most fifteen days along with the reeds or plates, so as to leave scarcely any scar.

Book VI, Section 9. ON BURNING OF THE EYELIDS BY MEDICINES.

The burning of the eyelids with caustic medicines was reprobated, in a word, by all the ancients, lest the acrimony of the application should prove injurious to the eyes; and because when the burning was carried to too great an extent the affection called lagophthalmos was produced, in which case the eyelids cannot be shut, and the vision is apt to be injured by everything that comes in the way. But since

many who suffer from the irritation of the ciliary hairs are not able to endure even the name of the operation by suture, we are compelled from necessity, against our will, to have recourse to burning by medicine. The following is a composition of that kind: of quicklime, p. ij; of Gallic or common soap, p. ij; and some add of aphronitrum, p. iv. These things being pounded with strained ley, or soap ley, or some other ley, as that of figs or of oaks, and being mixed with the urine of a young man not come to maturity, we apply to the eyelid, upon the knob of a specillum, the part touched having the shape of a myrtle leaf; and we burn to the extent comprehended in the operation by suture. The skin being burnt at the first application, we remove so much of it with a sponge, and apply the medicine a second time, allowing it to remain until the part blackens; and if it does not blacken we apply it a third time. When the skin is blackened and the eschar also formed, we must clean away the medicine and have recourse to bathing and washing until the eschar drop off; after which it will be proper to complete the cure by means of pledgets of charpie and emollient collyria.

Book VI, Section 10. ON LAGOPHTHALMOS OR HARE-EYE.

Those persons are said to have hare-eyes who have the eyelids drawn upwards. This complaint arises either naturally or from the cicatrix of a wound, and this may have occurred spontaneously, or from the operations of the suture or burning (as just mentioned) having been improperly performed; in which case even a moderate relief can only be accomplished when the eyelid is sufficiently thick. For we must divide the cicatrix, and having separated the lips with a tent, use bandages until the cure is completed, avoiding such things as are very desiccative, and having recourse to those which are fatty and relaxing, such as the juice of fenugreek poured on the part, and the ointment prepared with four ingredients called basilicon, applied on a tent.

Book VI, Section 11. ON THE SUTURE OF THE UNDER EYELID, AND THE BURNING OF IT BY MEDICINES.

The under eyelid is subject to the same complaints from the ciliary hairs as the upper; for, when larger than natural, it is everted; and it is subject likewise to phalangosis and distichiasis. We must, therefore, perform the operation of the suture in the same manner as for the upper eyelid, but in an inverted order, beginning with the *lunated* incision on account of the obstruction occasioned by the blood, and then making the *veruted*. But the *under-incision* is to be omitted altogether, because the lower eyelid, by its natural weight, is readily

everted. The rest of the treatment to be completed as in the suture of the upper eyelid, except that the extremities of the ligatures are not to be glued to the forehead. If in this case the patient is averse to an operation, and prefers burning by medicines, you have already got a description of this process.

Book VI, Section 12. ON ECTROPION, OR EVERSION OF THE LOWER EYELID.

Ectropion of the under lid is occasioned by the same causes as lagophthalmos of the upper, only that it does not occur naturally, but arises sometimes from relaxation produced by medicines possessed of this property, which have been applied for inflammation; and sometimes the eversion is occasioned by the suture or burning having been improperly performed. Taking, therefore, a needle, armed with a double thread, we perforate the fleshy mass, pushing it through from the left canthus to the right, and then by means of the thread fastened to both of its extremities, we stretch the skin with the needle, and cut down upon it with a scalpel, removing the needle at the same time. Then, if the eyelid resume its proper shape and is turned inwards, this operation will be sufficient. But if the eversion continue after the removal of the flesh, we apply the back of the specillum to the divided eyelid; and on the inside of the eyelid, having made two incisions, beginning at the two angles of the incision formerly made, and terminating in an acute point, and meeting together like the Greek Λ, we remove this substance, so that its acute point may be below at the eye, and the broad above at what is called the tarsus. Afterwards we unite the separated parts with a needle containing a woolen thread, being satisfied with two sutures. But if the ectropion be occasioned by the operation of the suture or burning we make a simple incision along the first cicatrix below the hairs of the tarsi, and having separated its lips, we fill up the wound with pledgets, using the same methods as for lagophthalmos (except fomentations) until the parts which have been stitched unite.

Book VI, Section 13. ON ANABROCHISMUS AND BURNING WITH IRON.

When the hairs which irritate the eye are not numerous, but only one, two, or at most, three, close to one another, we approve of the operation called anabrochismus. Taking, therefore, a very slender needle, we pass through its ear (eye?) a woman's hair or a fine flaxen thread, and unite the two extremities together in such a manner that the thread or hair which is passed through may have a double loop;

and we pass another such thread or hair through the loop, and pushing the needle through the tarsus where the preternatural hairs appear, we introduce the hair or hairs into the loop by means of an ear-specillum, and draw it upwards. And if the hair of the eyelash be fixed in it, we draw up the loop; but if one or more, fall out, we again, by means of the one at first introduced, draw down the loop, and once more introducing a hair or hairs, draw them upwards. But if there is only one slender hair that irritates the eye we draw up another of the ciliary hairs along with it, anointing them with gum or some other glutinous substance, and bending them until they unite to the skin. Some preferring burning to the operation of anabrochismus, turn the eyelid outwards, and with a hair-forceps dragging out the offending hair, if there is but one, or two, or three; if there be as many, they apply a double-headed specillum, or an ear-specillum, or some such small instrument heated, to the place whence the hair or hairs were removed. For the skin being thus constricted, no other hair is produced.

Book VI, Section 14. ON HYDATIDS.

The hydatid is a fatty substance, naturally lodged under the skin of the eyelid, which, in some persons, more especially in children of a more humid temperament, increases until it become the cause of disagreeable symptoms by encumbering the eye, and thereby occasioning defluxions. The eyelids, therefore, under the brows appear watery and cannot be raised in a becoming manner; and if, when we press upon them with our fingers, we separate the fingers, the intermediate space swells up. They are most troubled with defluxions about daybreak, and cannot look direct against the rays of the sun, but shed tears and are subject to continued ophthalmies. Wherefore, having placed the patient in a proper position, we compress the eyelid with the index and middle fingers a little separated from one another, so as to form a collection of the watery contents between the fingers, and direct the assistant, who stands behind and holds the head, to stretch the eyelid moderately at the middle of the brow; then taking a lancet used for bleeding, we make a transverse incision through the middle, not longer than that made in venesection, and of such a depth as to divide the skin or even to touch the hydatid itself; but this is to be done with due circumspection. For many plunging the instrument too deep, have either divided the cornea or wounded some muscle of the eyelid. If the hydatid immediately appear, we draw it out, or if not, we again make a slight incision. When it comes in sight we seize on it by the fingers, with a soft cloth, and moving it

hither and thither and round about, we draw it out. After the removal of it we soak a double compress in oxycrate, and bind it on the part. Some apply levigated salts, upon the knob of a specillum, to the incision, in order that if any part of the hydatid remain it may be dissolved. After the removal, should there be no inflammation, we accomplish the cure with collyria in the form of liniments, or with lycium, horned poppy, or saffron. But when there is inflammation we treat it with suitable cataplasms and the other remedies.

Book VI, Section 15. ON ADHESION OF THE EYELIDS.

The upper eyelid undergoes adhesion sometimes to the lower tarsus, sometimes to the tunica adnata, and sometimes to the cornea itself. This disease obstructs the motions of the eye. Wherefore, applying an ear-specillum to the broad margin of the eyelid, or stretching it with a hook-like instrument, we free the adhesion with the scalpel used in the operation for pterygia, taking care that the cornea be not wounded, lest we give rise to procidentia. After the incision, having bathed the eye, we separate the eyelids with tents, lest adhesion again take place, and applying wool, soaked in an egg, after the third day we have recourse to attenuant and healing collyria.

Book VI, Section 16. CHALAZIA OR TUMORS RESEMBLING HAIL-STONES.

The chalazion is a concretion of inert fluid in the eyelid. If it occur on the external side of the eyelid, having divided the outer part of the eyelid transversely with a scalpel, we extract the chalazion with an ear-pick, or some such instrument, and when the incision is large and the lips thereof separated, we unite them with a suture, and have recourse to some plaster. But if it be small we omit the suture and effect the cure in the same manner otherwise. But if the chalazion be internal, so as to appear through the cartilage, having turned the eyelid outwards, and divided it transversely within, we extract it and use an injection of salt water.

Book VI, Section 17. ON ACROCHORDON AND ENCANTHIS.

Acrochordon of the eyelid and that tumor at the greater canthus called encanthis we seize with a flesh forceps, and cutting them out with a scalpel, apply levigated chalcitis.

Book VI, Section 18. ON PTERYGIA.

This disease is occasioned by a nervous (tendinous) membrane beginning for the most part at the great canthus, and gradually spread-

ing inwards. It proves injurious to the eye both by obstructing the motion of the ball, owing to the contractions it produces, and because when it advances forwards it covers the pupil. Those therefore which are thin and of a white color being easiest to cure, we operate upon in this manner: having separated the eyelids, and seized upon the pterygia with a hook-like instrument, having a small curvature, we stretch it, and taking a needle having a horse-hair and a strong flaxen thread in its ear (eye?), and a little bent at the extremity, we transfix it through the middle of the pterygium, and with the thread we bind the pterygium and raise it upwards, while with the hair we separate and saw as it were the part at the pupil away unto its extremity; but the remainder of it at the great canthus we cut off from the base with the scalpel used for the operation by suture, but leaving the natural flesh of the canthus, lest there be a running of the eye when it is taken away. Some stretching as aforesaid with a thread, dissect away the whole pterygium with the instrument called pterygotomos, taking care not to touch the cornea. After the operation, having applied some levigated salts to the part, we bind on it some wool dipped in an egg. After the removal of this we inject into the eye salt water for a long time. But if inflammation supervene we have recourse to the remedies described for it.

Book VI, Section 19. ON STAPHYLOMA.

Staphyloma is an incurvation of the cornea, and of the tunica choroides, arising from debility, and being produced sometimes by a defluxion, and sometimes by ulceration. We operate upon it not in order to restore the eyesight, for that is impossible, but to moderate the patient's deformity. Wherefore having passed a needle from below upwards through the base of the staphyloma, we are to push another needle, having a double thread, from the canthus next the hand to the other, through the base of the staphyloma; and the first needle remaining, we cut the double of the thread, and tie part of the staphyloma upwards and part downwards with the threads, and then removing the needle we apply wool dipped in eggs. After the removal of the dressings we soothe the eyes with emollient injections until the ligatures fall off along with the staphyloma.

Book VI, Section 20. ON HYPOPYON OF THE EYE.

Regarding hypopyon of the eyes it will be sufficient to deliver Galen's account, which is to this effect:—"A certain oculist of our time, named Justus, cured many cases of hypopyon by shaking the head. Placing them, therefore, erect upon a chair, and grasping their

head on both sides obliquely, he shook them so that we could see clearly the pus descending downwards; and, owing to the weight of the substance, it remained below, although cataracts will not remain unless fixed carefully." And again, he says below, "oftentimes we evacuate the pus freely by dividing the cornea a little above the place where all the coats of the eye unite. This place is called by some the iris, and by others the corona." These are the words of Galen in his work, "*On the Method of Cure.*" After the discharge of the pus, we clean the ulcer with injections of honied water, or of the juice of fenugreek with the addition of some honey, and then apply the other treatment conformably.

Book VI, Section 21. ON CATARACTS.

The cataract is a collection of inert fluids upon the cornea at the pupil, obstructing vision, or preventing distinct vision. It arises most commonly from a congelation and weakness of the visual spirit, and on that account the disease rather attacks old persons, and those who are debilitated by protracted illness. It is occasioned also by violent vomiting, a blow, and many other causes. Those kinds of cataract which are but commencing, as not being proper objects of surgery, have been treated of in the Third Book. We shall now give the characters of those which are fairly formed and have acquired consistence. All those, therefore, who have cataract see the light more or less, and by this we distinguish cataract from amaurosis and glaucoma; for persons affected with these complaints do not perceive the light at all. Wherefore, again, Galen well instructs us as to the consistence and difference of cataracts and which kinds ought to be operated upon. Having shut the eye affected with the cataract, and with the large finger pressing the eyelid to the eye, and moving it with pressure to this side and that, then opening the eyelids and observing the cataract in the eye; if it has not yet acquired consistence, a certain flow takes place from the pressure of the finger, and at first it appears broader, but straightway resumes its former figure and magnitude. But in those which have acquired consistence no change takes place as to breadth or figure from the pressure. But since this appearance is common to those which are of moderate consistence, and those which are over-compacted, we distinguish these cases from one another by their color. For those which are of an iron, cerulean, or leaden color, are of moderate consistence, and fit for couching; but those which resemble gypsum and hailstones are over-compacted. After ascertaining these circumstances, as directed by Galen, having placed the patient opposite the light, but not in the sun, we bind up carefully the sound eye, and

having separated the lids of the other, at the distance from the part called the iris towards the small canthus, of about the size of the knob of the specillum, we then with the point of the perforator mark the place about to be perforated; and if it is the left eye we operate with the right hand, or if the right eye with the left; and turning round the point of the perforator, which is bent at its extremity, we push it strongly through the part which was marked out, until we come to an empty place. The depth of the perforation should be as great as the distance of the pupil from the iris. Wherefore, raising the perforator to the apex of the cataract (for the copper of it is seen through the transparency of the cornea), we push down the cataract to the parts below, and if it is immediately carried downwards, we rest for a little, but if it reascends we press it back again. After the depression of the cataract we turn round the perforator and extract it gently. After this, bathing with water and injecting into the eye a little Cappadocian salts, we apply externally some wool soaked in the white of an egg with rose-oil, and bind it up, and at the same time bind up the sound eye, that it may not move. Then lodging the patient in an apartment below ground, we order him to remain in a state of perfect rest, and upon a spare diet; and the bandages are to be kept on, if nothing prevent, until the seventh day, after which we loose them, and make trial of the sight by presenting him with some object: but this we disapprove of during the operation and immediately after it, lest by the intense exertion the cataract reascend. If the inflammation become urgent we loose the dressing before the seventh day, and must direct our attention to it.

Book VI, Section 22. ON ÆGILOPS, OR FISTULA LACHRYMALIS.

The ægilops is an apostematous swelling between the great canthus and the nose; and it is an affection difficult to cure, owing to the thinness of the bodies, and the fear of injuring the eye by sympathy. If, therefore, the abscess burst at the surface, we remove the whole protuberance as far as the bone; and if the fistulous sore incline toward the cheek, we must lay it all open, and if the bone be sound, we must scrape it; but if diseased, we must burn it with cauteries, applying to the eye a sponge soaked in cold water. Some, after the excision of the flesh, use a perforator, and make a passage for the fluid or matter to the nose; but we are contented with burning alone, using the cauteries for ægilops, and burning down until a lamina of bone drop off; and after the burning we have recourse to lentils and honey, or to the application consisting of pomegranate-rind with honey, and

other such desiccative remedies. If the ægilops incline to the canthus, and do not tend at all towards the surface, then, with a lancet for the operation on pterygium, or one for bleeding, we may dissect out the body between the canthus as far as the abscess, and remove the deep-seated flesh, and have recourse to moderately desiccative applications. Glass reduced to a fine powder is wonderfully desiccative, and aloes with manna, in like manner. The rest of the treatment of fistula lachrymalis we have delivered in the Third Book.—(T. H. S.)

Paul, St., of Tarsus.[1] Before the conversion by him of Sergius Paulus (whose name he seems to have taken on that occasion) he was known as Saul. He is also called "Paul, The Apostle" and "The Apostle to the Gentiles." One of the apostles of Jesus, of special interest to ophthalmologists because of the blindness from which he suffered in connection with his conversion to Christianity.[2] Saul, the Paul that was to be, was the son of Hebrew parents (his father, in fact, was a Pharisee, and of the tribe of Benjamin), but was born in a Gentile City, namely, Tarsus, a place of learning and elegance in Asia Minor. Here he acquired, of course, the Greek language, and (in accordance with Hebrew custom, in families of every social rank and degree of wealth) acquired a mechanical trade, namely that of tent-maker.

When still a boy, he removed to Jerusalem, for the sake of a Hebrew education. Here, as he himself has told us, he studied "at the feet of Gamaliel."

In the earliest days of Christianity, Saul was probably the most enthusiastic of all the persecutors of the deeply hated Christians. "As for Saul, he made havoc of the Church, entering into every house, and haling men and women, committed them to prison" (*Acts*, viii, 3). When Stephen was stoned, "the witnesses laid down their clothes at a young man's feet, whose name was Saul. * * * And he [Stephen] kneeled down, and cried with a loud voice, Lord, lay not this sin to their charge. And when he had said this, he fell asleep. And Saul was consenting unto his death." (*Acts*, vii, 58, 60; vii, 1.)

Shortly afterward came that marvelous alteration, that miraculous change in the life and character of Saul of Tarsus which has been a favored theme in sermon, song and story even to the present moment. The original account is rendered by the man himself (*Acts*, ix, 1-21) as follows: "But Saul, yet breathing threatening and slaughter against the disciples of the Lord, went unto the high priest, and asked of him letters to Damascus unto the synagogues, that if he found any

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[1] Nearly all our primary sources for a knowledge of the life of St. Paul consist of the *Acts of the Apostles* and the Pauline *Epistles*.

[2] For a case of blindness *inflicted* by St. Paul, see, in the Appendix to this *Encyclopedia*, **Bar-Jesus** and **Elymas**.

that were of the Way, whether men or women, he might bring them bound to Jerusalem. And as he journeyed, it came to pass that he drew nigh unto Damascus: and suddenly there shone round about him a light out of heaven: and he fell upon the earth, and heard a voice saying unto him, Saul, Saul, why persecutest thou me? And he said, Who art thou, Lord? And he said, I am Jesus whom thou persecutest: but rise, and enter into the city, and it shall be told thee what thou must do. And the men that journeyed with him stood speechless, hearing the voice, but beholding no man. And Saul arose from the earth; and when his eyes were opened, he saw nothing; and they led him by the hand, and brought him into Damascus. And he was three days without sight, and did neither eat nor drink.

"Now there was a certain disciple at Damascus, named Ananias; and the Lord said unto him in a vision, Ananinas. And he said, Behold, I am here, Lord. And the Lord said unto him, Arise, and go to the street which is called Straight, and inquire in the house of Judas for one named Saul, a man of Tarsus: for behold, he prayeth; and he hath seen a man named Ananias coming in, and laying his hands on him, that he might receive his sight. But Ananias answered, Lord, I have heard from many of this man, how much evil he did to thy saints at Jerusalem: and here he hath authority from the chief priests to bind all that call upon thy name. But the Lord said unto him, Go thy way: for he is a chosen vessel unto me, to bear my name before The Gentiles and kings, and the children of Israel: for I will show him how many things he must suffer for my name's sake. And Ananias departed, and entered into the house; and laying his hands on him said, Brother Saul, the Lord, even Jesus, who appeared unto thee in the way which thou camest, hath sent me, that thou mayest receive thy sight, and be filled with the Holy Ghost. And straightway there fell from his eyes as it were scales, and he received his sight; and he arose and was baptised; and he took food and was strengthened.

"And he was certain days with the disciples which were at Damascus. And straightway in the synagogues he proclaimed Jesus, that he is the Son of God. And all that heard him were amazed, and said, Is not this he that in Jerusalem made havock of them which called on this name? and he had come hither for this intent, that he might bring them bound before the chief priests."

Of the subsequent life of Paul we have no warrant to write here, except in scantiest outline. Suffice it, then, to say that, after his conversion, the Apostle, now called Saul, entered on the performance of his labors at Antioch, then went upon his mission, or visit, to Arabia; next upon his missionary journey to Eastern Asia Minor; following

that, made the celebrated visit to Jerusalem, there to settle certain matters of Jewish (now Christian) law; then again, departed for Europe, there to introduce the Gospel; then came still another missionary journey, including a sojourn at Ephesus, then his arrest at Jerusalem, his imprisonment at Cesarea, and, finally, his voyage to Rome. Then, for a time, the authorities are silent concerning the life of St. Paul. It has, however, been supposed that, after an imprisonment of two or more years at Rome, the Apostle was given his liberty and went upon various missionary journeys both to the East and to the West. After that, the writings speak again. The Apostle was again arrested and taken to the city of Caesar. Here he composed the last of his epistles, that to Timothy, and was beheaded, either precisely or nearly at the same time as that at which St. Peter (also at Rome) was crucified.—(T. H. S.)

Pauli, Friedrich. A distinguished German surgeon and ophthalmologist, the first to perform (though unsuccessfully) a strabismus operation on the living subject, and introducer of the terms, phacomalacia, phacoscleroma, phacohydropsia, and staphylhematoma. Born Feb. 3, 1804, at Landau in the Palatinate, he studied at Strasburg and Göttingen, at the latter institution receiving his medical degree in 1824. He afterwards completed his medical training at Berlin, Munich, Prague, Vienna, and Paris. In 1828 he settled at Landau, where he practised for forty years, dying Jan. 21, 1868.

Pauli's ophthalmic writings are as follows: 1. Ueber den Grauen Staar und die Verkrümmungen und eine neue Heilart dieser Krankheiten. (Stuttgart, 1838.) 2. Sublatio Cataractae. (*Ammon's Monatsschr.*, I, 1838, 97-115.) 3. Mémoire sur la Nature de l'Ophtalmie d'Egypte. (Stuttgart, 1858.) 4. Ueber Sklerektomie. (*Heidelberger Med. Annalen,* III, 1837, p. 255.) 5. Untersuchungen und Erfahrungen auf dem Gebiete der Chirurgie. (Leipsic, 1844.)—T. H. S.)

Paullinia grandiflora. A Brazilian species. The leaves are used for diseases of the eyes.

Paulos of Ægina. A famous surgeon, obstetrician and ophthalmologist of the Greek middle ages. See **Paul of Ægina.**

Paulus Ægineta. A famous surgeon, obstetrician and ophthalmologist of the Greek middle ages. See **Paul of Ægina.**

Paupière. (F.) Eyelid.

Paupières en besac. (F.) Blepharochalasis.

Pavonia coccinea. "Scarlet mallow" of the Antilles. The flowers are used externally in eye diseases.

Pavy's disease. Recurrent albuminuria.

Pearl cysts of the iris. See p. 3675, Vol. V, of this *Encyclopedia.*

Pearl tumors. A name for pearl cysts of the iris.

Pebble. Rock crystal. Brazilian pebbles are very pure pieces of rock-crystal formerly used for making spectacle lenses.

Peck, Edward Sprague. A well known New York ophthalmologist and oto-laryngologist, the son of Theodore Augustus and Delia Horton Safford Peck. He received the degree of Bachelor of Arts at the University of Vermont in 1864, and the medical degree at the same institution in 1868. Having practised both in Vermont and in New York City for a number of years, he went abroad and studied ophthalmology at Berlin, Erlangen, Zürich, Vienna and London.

Having served for a time in the Turco-Servian war, Dr. Peck returned to the U. S. in 1878. Settling in New York as ophthalmologist and oto-laryngologist, he became professor of diseases of the eye at the University of Vermont, but continued to reside in New York City. He was a member of a number of medical societies, and held, at various times, a number of hospital appointments.

Dr. Peck died at his home in New York City early in 1915.—(T. H. S.)

Pecten. Marsupium, or "comb," found in the eyes of birds and reptiles. See **Comparative ophthalmology.**

Pecten scleræ. The name given to the crust-like margin of the sclera—sometimes called the *scleral rim*—around the entrance of the optic nerve.

Pectinate. Comb-like; having teeth or tooth-like projections like those of a comb.

Pectinate ligament. See **Ligament, Pectinate,** p. 7468, Vol. X of this *Encyclopedia.*

In addition to the matter there detailed the work of Thomson Henderson (*Ophthalmic Review*, p. 30, 1908) seemed to demonstrate that the theory hitherto held of the pectinate ligament being formed by the splitting up of Descemet's membrane was erroneous. The appearance so described was due to the fact that the direction in which sections have been cut has generally been faulty; if accurately radial transverse sections are taken the following points can be made out. The pectinate ligament is a non-sclerosed part of the sclera, and is in direct continuity with the posterior layers of the cornea; as these fibres pass backwards they divide into two sets, a small outer one going into the sclera behind the canal of Schlemm, and an inner one which again subdivides into two portions, one going through the scleral ring and another internal to the scleral ring. The outermost part of this bundle gives attachment to the meridional fibres of the ciliary muscle, while the inner bundle passes backwards and inwards into

the ciliary body and affords attachment to the intermediate fibres of the ciliary muscle, terminating in the connective tissue stroma of the circular muscle. The inner or ciliary set is simply part of the attachment of the whole of the ciliary muscle. The open network of the ligamentum is completed by the interlacing of the circular fibres of the sclera which surround the canal of Schlemm. None of the fibres of the pectinate ligament pass round into the root of the iris, and the criterion of an accurately radial section is that it shows a direct continuity between the hyaline layer of the ciliary body and the posterior limiting layer of the iris. This arrangement opens up a connection not only between the anterior chamber and Schlemm's canal, but also between the anterior chamber and the suprachoroidal space. Henderson suggested the name of "Cribriform ligament" as more appropriate than pectinate ligament, in view of this anatomical arrangement.

Pedagogy, Ophthalmic. See **Teaching methods, means and appliances in ophthalmology.**

Pediculosis, Ocular. See **Louse,** as well as p. 7447, Vol. X and p. 1031, Vol. II of this *Encyclopedia,* also **Parasites, Ocular.**

Pedigree charts. See **Familial eye affections.**

Pedigree, Color-blindness. See p. 5868, Vol. VIII of this *Encyclopedia.*

In addition to what is there found Nettleship (*Roy. Lond. Oph. Hosp. Reports,* Vol. XIX, pt. 1, 1915) describes three pedigrees of achromatopsia, as follows:—1. A pedigree of color-blindness, including color-blind females. The interest of this pedigree is principally with regard to the inheritance of color-blindness in females, and as to whether it is essential for the occurrence of color-blindness in a female that the father be color-blind and the mother capable of transmitting color-blindness.

2. A pedigree of color-blindness which shows seven color-blind males, one a twin, in four sibships of two consecutive generations. All are descended from parents who, as far as is known, had normal color-vision, and there is nothing to indicate that the inheritance of color-blindness was not according to rule in any of the cases. Amongst the members with normal color-vision occur congenital deformity, hare-lip, and insanity.

3. An extension of a pedigree of color-blindness that was published by Pliny Earle in 1845.

Pedigree symbols. See **Familial eye affections.**

Pege. (Obs.) Internal canthus.

Pegged teeth. See p. 6068, Vol. VIII of this *Encyclopedia.*

Pegology. The science of medicinal mineral springs. The term has been proposed as a substitute for balneology.

Peliosis rheumatica. Rheumatic purpura, or rheumatism with a purpuric rash.

Pellagra, Ocular signs of. An endemic skin and spinal disease of southern Europe cases of which have recently been seen in the southern and central parts of the United States. It is said to be caused by eating damaged or diseased maize (corn), but is dependent also upon bad hygienic conditions, lack of proper food, and exposure to the sun. By some it is believed to be conveyed by the insect *Similium reptans*. It is marked by a recurring erythema of the surface of the body, which is followed by exfoliation of the epidermis. There are weakness and debility, digestive disturbance, spinal pain, convulsions, melancholia, and idiocy. It is called also *Italian leprosy* and *Lombardy leprosy*.

It is questionable whether there are any ocular lesions—probably few symptoms—characteristic of this disease.

The frequency of this disease in South Carolina has given Whaley opportunity to examine 18 cases, all among the insane. Hypersensitiveness to light, with contracted pupils, was the rule. In only one case was the pupil dilated. In 2 cases it was especially resistent to the action of homatropin; in others this drug produced its usual effect. There was one case of loss of reflex contraction to light (Argyll-Robertson symptom). The anterior chamber was commonly shallow, but in only one eye was there increased intraocular tension. In six cases the corneal sensibility was below the normal, in 2 cases it was increased. Strabismus and nystagmus were not met with. In 5 cases, all of which had the mucous membranes very much affected, there was some obstruction of the lachrymal duct. The retina, optic nerves, and other internal parts of the eye, presented no lesions.

In this disease A. B. Clarke (*Medical Record*, Dec. 18, 1909) has found no peculiarities in the symptomatology, characteristic appearances, or complications in diseases of the eye occurring in pellagra, except that they are prone to exhibit the same cycle—a recrudescence in early spring time and recovery as summer progresses. His observations were upon rice-field negroes, who are inured to hardships, poorly educated and poorly nourished. He recites the histories of six cases.

Case 1 presented ectropion, conjunctivitis, slight vitreous opacity and signs of choroidal atrophy. Case 2 presented the signs of vernal catarrh; the fundus showed a dark black spot similar to retinitis pigmentosa, but limited to about 4 mm. around the disc and involving the macular region. Case 3 complained of pains in the eyes, with burning sensation and failing vision, and had beginning optic nerve

atrophy. Case 4 showed corneal opacity with small ulcers, irregularly dilated pupil, posterior synechiæ, hazy aqueous and vitreous of one eye; in the inner canthus of each eye was a small papilla which exuded watery substance upon being punctured. Case 5 showed iritis of the right eye; there were no fundus changes. Case 6 complained of smarting pains in both eyes and each morning had a bluish film over the cornea; after six weeks there was no ocular complaint; ophthalmoscopically, the arteries were found very small, the veins enlarged, and there were small hemorrhages near the disc.

Pelle. (F.) Scoop.

Pelletierin, Oculotoxic symptoms from. This drug is an alkaloid, or mixture of alkaloids, from the pomegranate, *Punica granatum*, stem, root and bark. A number of salts of this agent are known but none of them, so far as we are aware, is used in ophthalmic therapy excepting the hydrobromide. It is a brownish, viscid liquid and in doses of from 5 to 8 grains has been recommended in pareses of the ocular muscles with good results.

The poisonous effects of this agent including oculotoxic symptoms are the same as that of Punica granatum. Sidler-Huguenin has reported a case of amblyopia from the alkaloid (blindness at first followed by some improvement in vision) associated with atrophic pallor of the optic disk and changes in the retinal vessels.

Pellicle. A thin skin or film.

Pellidol. This agent is a diacetyl derivative of amidoazotoluol; it is insoluble in water, but soluble in ether, alcohol, vaselin and oils. A 2 per cent. ointment usually suffices. It is non-irritant and, unlike scarlet red from which it is derived, does not stain the parts to which it is applied.

Haas (*Woch. f. Th. u. Hyg. des Auges*, July 24, 1913) finds that an additional antiseptic action is procured by combining pellidol with an albuminous iodin preparation (iodolen), which contains 30 per cent. iodin. A mixture of equal parts of pellidol and iodolen is sold under the name of azodolen.

The writer found both preparations unirritating and of value in phlyctenular affections of the eye, massage every other day with pellidol or azodolen ointment acting very favorably. In refractory relapsing eczematous keratitis especially good results were obtained. In a few of these cases he resorted to an oily solution with or without a mydriatic.

In uncomplicated corneal infiltrates with intact epithelium the results were less favorable; not until the epithelium had broken down did a favorable result follow. In superficial abrasions of the cornea the drugs act disadvantageously, causing hyperproduction of epithe-

lium, thereby keeping the eye irritated for days. In infectious conditions of the conjunctiva no striking results were obtained.

Dutoit (*Oph. Year-Book*, p. 38, 1914) reports favorable experiences in the use of a 2 per cent. salve in cases of eczematous keratoconjunctivitis, simple ulcers of the cornea, relapsing eczematous keratitis, injury of the cornea by foreign bodies with resulting infiltration, and catarrhal ulcers of the cornea. After each application of the salve the eye is kept bandaged.

Pellier de Quengsy, Guillaume. A famous Montpellensian ophthalmologist, renowned for having invented a number of modifications in the cataract operation, and for having produced the first extensive work devoted to ocular surgery exclusively. He was born in 1750 or '51, the son of a surgeon and ophthalmologist of some repute, who was, in fact, a Master of Surgery as well as the city ophthalmologist at Bar-le-Duc and Metz. The subject of this sketch had an elder brother who was an ophthalmologist for years at Nancy, France. He then practised both in England and in Scotland where he rose so high in favor that he received the freedom of the city of Aberdeen.

The younger brother—the more immediate subject of our attention and by far the greatest personage of the three—received his medical degree, presumably in France but no one knows exactly where. He studied ophthalmology with his father, restricted all his practice to the one specialty (a somewhat rare proceeding, or exclusion, in those days) and, by 1772, was becoming well known in his branch.

There was always a little of the charlatan in Pellier de Quengsy, a fact to be accounted for, in part at least, by the low ideals of the time. Thus, he was, throughout the earlier portion of his career, decidedly itinerant. According to Truc and Pansier: "If we follow him in his peregrinations as a nomad oculist, we find him at Auxerre in July, 1772, at Langres in April and May, 1773, at Avalon in July, at Thonon de Savoie in October. In January, 1774, he is at Verdun, in February at Varennes and Sainte-Ménéhold; on the 20th of May, he operates at Angoulême. From there he goes to Valenciennes. In June he is at Brussels; in July at Noyon; in August at Beauvais; in September at Chartres; in November at Evreux, finally at Toulouse, where he established himself for a time, pensioned by the city. In February, 1775, he makes a tour to Rheims, and finds himself at Poitiers in April. He returned to Toulouse, whence he makes frequent excursions to Agen and Bordeaux."

In 1776, however, he seems to have tired of his Bedouin life and to have made himself a permanent home at Montpellier. In 1799, he was one of the founders of the Society of Practical Medicine at Mont-

pellier. In 1810 and again in 1822, his name appears as that of an ophthalmologist on the membership roll of the same institution. He was also for a time the president of this society. In 1779 he became brevetted oculist to the city. However, in spite of his fixed abode for many years at Montpellier, he made a large number of professional journeys at this very epoch of his life—to Marseilles, Mînes, Toulouse, Dijon, Besançon, Varennes, and even to Colmar and Strasbourg. Besides his wandering tendency, he was not averse to the use of the public prints for the purpose of increasing his reputation with the laity; but it must be said in this connection that never does he seem to have told an untruth in any of his advertisements, in fact his use of printer's ink was chiefly for the purpose of exposing lies which he had found in the advertisements of other ophthalmologists.

At the time of the Revolution he dropped the words, "de Quengsy," from his name, and became a simple citizen as "Guillaume Pellier."

He died November 21, 1835, aged 84.

Pellier was a man of great influence in his day and generation. Though he left no epoch-making discoveries, he was, beyond a doubt, a man of excellent judgment, a cool, rapid and successful operator. He was also a clear and forceful writer. He was mostly known, however, in the way of innovations, for his highly ingenious instrument, the "ophthalmotome," a device whereby the inventor performed a cataract extraction almost "in the twinkling of an eye," and with only a single instrument. The instrument consisted of a small, pointed knife, the handle of which was hollow, while the sickle-shaped blade was slightly curved upon the flat. The convex border of the blade was the cutting edge, which was an inch and three lines in length. The blade was one and two-thirds lines in breadth, at its broadest portion.

By means of an appropriate mechanism, the blade could be returned to the hollow handle, after use, while the little spoon could be made to protrude from the opposite extremity of the convenient tube.

With this instrument Pellier performed his cataract extraction as follows: Let us assume that the eye to be operated on is the left one. While an assistant held the upper lid away from the field of operation, and the operator himself steadied the bulbus by means of the left middle finger (which he pressed against the nasal aspect of the ball), the "ophthalmotome" was taken up pen-fashion by the fingers of the operator's right hand, and then the cornea was punctured, the capsule was transfixed, and the corneal counterpuncture effected, almost at a single movement. The incision included, in the usual case, about two-thirds of the corneal circumference. Above the wound a little

pressure was then made with the flat of the instrument, and, below the wound, with the index finger of the left hand. The lens mass once outside the eye, the remaining fragments of the lens, if any, were removed by means of the little spoon.

In the case of the right eye, the proceeding was exactly the same, except that the index finger of the operator's right hand was used to steady the eye, while the instrument itself was manipulated by the fingers of the left hand.

Pellier was not the first, however, to perform a capsulotomy between corneal puncture and counterpuncture. This honor belongs to Ten Haaf. In this particular matter Pellier was possibly second, but, more probably, third. Pellier, however, with his cleverly devised "ophthalmotome" did much to simplify the extremely complicated procedure of Daviel and his more immediate successors.

Pellier's most important writings are as follows:

1. Récueil des Mémoires et d'Observations tant sur les Maladies qui Attaquent l'Oeil et les Parties qui l'Environment," etc. (Montpellier, 1783.)

2. Précis ou Cours d'Opérations sur les Yeux Puisé dans le Sein de la Pratique et Enrichi de Figures en Taille-douce qui Représentent les Instruments qui leur Sont Propres, avec des Observations," etc. (2 vols.; Paris and Montpellier; 1789 and '90. The first extensive work to be devoted to the surgery of the eye exclusively.)

3. Observations sur l'Utilité de l'Arteriotomie dans l'Amaurosis ou Goutte Serene Provenant d'un Engorgement Sanguin. (*Jour de Méd. de Mont.*, 1803.)

4. Mémoire sur la Conversation de la Vue. (*Hist. et Mém de la Société de Méd. Prat. de Montpellier*, 1806.)

5. Sur l'Utilité du Séton Appliqué a l'Oeil Affecté de Maladies de Maladies Graves. (*Jour. de Méd. de Montpellier,* XXII, 1813.)—(T. H. S.)

Pellotin, Oculotoxic symptoms from. See **Anhalonium Lewinii**, p. 478, vol. I of this *Encyclopedia*.

Pellucid. Translucent.

Pelorus. An instrument for detecting errors of the compass by the bearings of celestial objects.

Pelosin. Colorless alkaloid from the root of *Cissampelos pareira*, said to be identical with bebeerin.

Pemberton, Henry. A London ophthalmologist, to whom we owe the words "accommodate" and "accommodation." Born at London in 1694, he received his professional degree at Leyden in 1719, and practised for a time at Paris. Soon, however, because of ill health,

he resigned his medical practice, and became a student of mathematics. He died Mar. 9, 1771.

His writings are as follows:

1. Dissertatio Physico-Medica Inauguralis de Faculate Oculi qua ad Diversas Rerum Conspectarum Distantias se Accomodat pro Gradu Doctoratus Eruditorum Examini Submittet Henricus Pemberton, Anglo-Britannus, ad diem 21. 1719, Lugduni Batavorum.*

2. Transalation and Improvement of the London Dispensatory. (London, 1746.)

3. A course of Lectures on Physiology. (London, 1773.)—(T. H. S.)

Pemfigo. (It.) Pemphigus.

Pemphigus, Ocular. Pemphigus is an acute, or chronic, disease of the skin and mucous membranes, characterized by the formation of rounded or oval blebs, arising from apparently normal surfaces, which may or may not be accompanied by constitutional symptoms, in grave cases so severe that death results.

Dermatologists divide pemphigus into the acute and the chronic forms, as well as the foliaceous and the vegetans; and they apply the terms benign, malignant, gangrenous and hemorrhagic to describe the aspects of the disease.

Acute pemphigus is characterized by the sudden eruption of bullæ which appear in crops. The bullæ, which may be small or quite large, are developed on sound skin, their contents clear at first, soon become opaque or hemorrhagic, or, in rare instances, gangrenous. In mild cases the blebs become absorbed under dry crusts, complete recovery taking place without scarring.

Chronic pemphigus runs a long course, the bullæ continuing to appear and reappear either singly or in crops, the skin generally being not without a few lesions. Cycles of attacks may be noted with intervals of complete rest, or single lesions may appear day after day for a long period, until they are rather suddenly followed by a numerous crop of fresh bullæ. Although blood may be found mixed with the contents, the lesions usually heal by crusting without scarring. Frequently the mouth and throat may exhibit similar blebs and, though rarely, the conjunctiva too may be attacked.

Despite the apparent mildness of the lesion, pemphigus is a rare disease; it attacks all ages and both sexes, although it is not at all hereditary. The etiology is obscure, for acute pemphigus has followed vaccination, rheumatic and other fevers, sepsis, diphtheria, puerperal

* For the correct title of this book I am indebted to Professor Hirschberg, who points out an error in the name as given in the "*Biogr. Lexikon der Hervorrag. Ärzte.*"

and menstrual disorders, and it has been seen in debilitated subjects after long confinement in badly-ventilated rooms. As it has been found in butchers and meat-handlers with wounded and infected hands, it may in them, in certain of its characterictics, be said to resemble the "foot and mouth disease."

The extent of the changes in the skin occasioned by the bullæ of pemphigus depends upon the degree of the inflammation excited by the bullæ and the stage of the bullous development, as it may involve not only the various layers of the epithelium but also the whole epithelium may be raised above the surface. The roof of the bleb usually is formed of the upper part of the horny layer, the base of the rete cells, extending to the corium in deeply situated blebs; their contents consist of serum, pus cells and fat. The papillæ are found to be edematous, their cells dilated, and the tissues infiltrated with serum into which leucocytes have wandered. The formation of the bleb is due probably to a sudden effusion followed by paralysis and dilatation of the vessels of the papillary layer.

Pemphigus is to be distinguished from 1st, bullous erythema multiforme, which affection, however, rarely attacks the mucous membrane and it is seen chiefly on the extremities. Erythema is mild in its manifestations, commonly appearing in the spring and autumn months and exists for only a few days, while pemphigus may appear at any season becoming chronic in its course and invariably gives rise to more or less systemic derangement. 2nd, Bullous impetigo contagiosa, which is prone to attack infants, affecting chiefly the face, although it may become generalized. 3rd, Dermatitis herpetiformis, in which disease there are vesicles, bullæ, papules and pustules which manifest the tendency to gather into groups, and it is accompanied invariably by itching. Impetigo affects chiefly the face and extremities, the mucous membranes being seldom if ever attacked, while constitutional symptoms are practically wanting. 4th, Bullous syphiloderm, too, may present features resembling pemphigus, but the syphiloderm is seen in young infants in whose parents may be manifested the signs of luetic infection, and the child itself frequently gives indubitable evidences of that disease. 5th, Eczema may simulate pemphigus, although eczema is rarely seen in bullous blebs, and, as a rule, the mucous membrane is not invaded, and it usually presents erythema, vesicles and crusts as well, and is accompanied by intense itching.

The prognosis of pemphigus is uncertain, because it must be based upon the severity of the general symptoms, the type of the lesions and the variety of the disease. Septic cases are grave; the hemorrhagic, purulent and gangrenous are usually fatal. In chronic cases death is

likely to ensue, because of the exhaustion attending the frequent eruptions and relapses.

Pemphigus presents many aspects and forms, but it is most frequently seen in the chronic form. Typical cases show oval bullæ of from ¼ to 1 inch in diameter with tense walls and translucent contents. They often appear in crops and the bullæ manifest a tendency to coalesce; they are bilateral in their distribution, but are more abundant on the face and trunk than on the extremities. The duration of each bleb is for a few days only, but the duration of the disease itself may persist indefinitely.

Pemphigus is a malady the lesions of which consist primarily of distinct watery rounded blebs, without rings, manifesting no tendency to become arranged in groups, but appear in successive crops, of more or less general distribution, and, as a rule, they run a chronic course with exacerbations. It is of uncertain origin and it is equally uncertain as to its type as a dermatologic entity. Many clinicians still consider it to be included under what Duhring classified as dermatitis herpetiformis.

The disease may be found on the mucous membranes, but so far as is known the lesions have not occurred in the intestinal tract, but have been confined to the orificial portions of the membrane as of the pharyngeal, the vaginal and the rectal. It may, however, and does affect the conjunctiva; in eight cases in Morris' series the disease first attacked the eye. Acute pemphigus may end fatally; and severe cases of naso-pharyngeal pemphigus ultimately lead to the death of the patient from marasmus, yet as a rule the progress of the general disease is not so baneful as when it attacks the conjunctiva, for there the effects of the disease are invariably followed by extensive shrinking of the tissues and the destruction of the secretory powers.

Pemphigus of the eye, prior to the middle of the 19th century, was classified with the urticarias and with scabies of the face and eyes, although its true nature was recognized by Wichman so early as 1800, yet, it was White Cooper, in the first volume of the *Royal London Ophthalmic Hospital Report* for 1858, who considered it to be a distinct affection. Stellwag, in 1870, decribed the condition as "sydesmitis degenerativa," and Kries characterized it as an "essential shrinking of the conjunctiva," nevertheless it remained for von Graefe to obtain for it a secure position, for he too, in 1879, called it "essential shrinking of the conjunctiva," and he believed the condition to be analagous to pemphigus of the skin, and accordingly this dictum is accepted by most observers to-day.

Pemphigus itself is so rare an affection that it is not seen more

than once in 500 cases of skin diseases in this country and in England, although it is seen more frequently in Europe, consequently pemphigus of the eye must be extremely uncommon. Not many cases affecting the eye have been reported in America; Casey Wood has reported that he has seen but three cases in twenty-five years of his practice; Weidler has reported two cases; Santos Fernandez, of Havana, speaks of having seen three in 50,000; Horner placed the proportion at three in 70,000; Pergens two in 22,000, and I have seen it but once and then when the disease was in the late stage of shrinking and of symblepharon.

The ocular affection is usually bilateral, though often to unequal degrees of intensity in the two eyes; but in this tendency to symmetry it contrasts notably with the skin lesions.

There seems to be no constant relation between the duration of the skin affection and the development of the ocular lesions, yet, in some cases only a few weeks have been known to elapse between the time of the first appearance of the bullæ on the skin and the implication of the conjunctiva. In other cases it may be presumed that the association has been closer still, inasmuch as the lesions of the skin or mucous membranes may have been absent for a time or they may have been overlooked, and in this regard it cannot be too strongly emphasized that without coincident pemphigus of the integument a positive diagnosis of ocular pemphigus cannot be made. The affection may have begun as a general pemphigus but the conjunctiva may not have been attacked for some years later; so too, it has been known to arise primarily on the conjunctiva and later involve the skin. No instances have been reported of conjunctival lesions in acute pemphigus. The symptoms of the disease of the conjunctiva, just as in the dermal manifestations depend for their severity upon the extent or the depth to which the membranes are invaded.

General pemphigus is more common in children, but ocular pemphigus is, on the average, an affection of later life; of 25, in the collection of 28 cases by Morris and Roberts, the average age was 41, the youngest being 24, the eldest 76 years, while only three of the series were of small children.

Pemphigus may appear in many and various forms, modified, of course, by the character of the tissue upon which it is found; therefore, pemphigus may be divided clinically into cases presenting blebs on the skin; others of the mucous membrane with blebs in the mouth, the nose and the larynx, or else in those rare instances in which the disease is localized on the conjunctiva, and in others it has assumed the characteristics of an essential shrinking of the conjunctiva, certain cases of which have looked like trachoma.

The subjective symptoms of pemphigus are not at all distinctive nor characteristic, but consist usually of soreness, tenderness, burning and occasionally itching. But when it attacks the conjunctiva especially in the early stages, there is slight photophobia with lachrymation, which may become so marked that the discharge is free and the lids stick together, which discharge speedily recurs after cleansing. The disease may begin with blisters on the skin of the eyelids, which soon pass over and invade the conjunctiva. The conjunctiva then becomes swollen and red. The bullæ are rarely seen on the mucous membrane because probably of the delicacy of their structure, and it is commonly the case that by the time of the first examination they have already ruptured so that the conjunctiva exhibits grey, necrotic areas or patches deprived of epithelium and covered with grey, lardaceous secretion. Bullæ are found only exceptionally because the epithelium of the conjunctiva is so soft and delicate that it cannot be lifted up by the serous exudate in the manner in which the skin can be in broad layers, but it speedily ruptures and in consequence is thrown off in shreds, the areas of necrosis following.

The inflammatory reaction following the formation of the bullæ soon penetrates the subconjunctival tissues and is accompanied by the formation of new blood vessels with walls so tender that they bleed on the slightest efforts to expose the cul de sac. The areas are rapidly converted into cicatrices, and, while this process is going on fresh blebs and ulcers appear in other places. The cicatrization is accompanied by excessive contraction, which may include the tarsal plates so that they become thickened and mis-shapen. The conjunctival membrane shrinks, becomes opaque, white and tense, while the folds disappear and bands form extending from the globe to the lids. The lachrymal ducts may be occluded, and the conjunctiva becomes dry. Eventually the lids retract, causing entropion and symblepharon. It is not at all improbable that in cases of so-called spontaneous symblepharon posterior, the adhesions found in the conjunctival sac have arisen from attacks of pemphigus which were unrecognized in their incipiency.

The cornea is not attacked primarly, but only by an extension of the conjunctival process; therefore, as a usual thing involvement of the cornea is seen only in the late stages of the affection. In pemphigus there is not found that tendency to ulcerative destruction of the cornea which is so commonly the case in xerosis of the conjunctiva, yet ulceration and suppurative keratitis may be found early in the course of the disease, accompanied by perforation and destruction of the cornea followed by prolapse of the lens and vitreous, while in the last

stage there may supervene buphthalmos, staphyloma, panophthalmitis and phthisis.

Von Graefe pointed out that pemphigus consisted essentially of shrinking; or atrophy of the conjunctival tissues without antecedent hypertrophy. Gelpe, Sattler, and Pflüger believed the shrinking to be dependent upon the formation of vesicles and bullæ within the conjunctival tissues.

The pathology therefore, is obscure, but according to Sattler, the swelling of the conjunctiva is caused by the swelling of the connective tissue bundles and to the expansion of the spaces which have become filled with liquid, but not, as was once thought, to the infiltration of the conjunctiva with lymphoid cells. The sub-epithelial layer of the conjunctiva forms an especially modified membrane which might easily be mistaken for the epithelium itself, although it is more turbid and more opaque than the rest of the tissues, and it runs parallel with the surface of the conjunctiva and extends over the cornea. The ulcers are likely to be covered by a pseudo-diphtheritic membrane formed by the fibrous coagulation of their contents. The entire stroma of this layer becomes pervaded with granular bodies which do not stain with hematoxylon nor with Bismarck brown. The blood vessels of the conjunctiva are numerous and much congested, although they may not have been apparent on a superficial view of the conjunctiva, because they were concealed by the condition of the epithelium. The epithelium loses its normal characteristics, and consists of the horny cells from the deepest layers together with the most superficial and it cannot be separated easily from the underlying conjunctiva. The cornea is soon transformed into vascular scar tissue becoming covered by horny epithelium lying on hypertrophied fibrous tissue.

Collins in his study of two cases found distinct alterations in the corneal membrane, which besides showing a greater degree of convexity presented on the anterior surface a layer quite different from the normal epithelium. The epithelial covering was thicker than the normal and from it a number of finger-like processes dipped down into the fiber layers, which layer showed areas of round-cell infiltration and newly-formed blood vessels, while Descemet's membrane, in each case, was absent in places.

All efforts at the bacteriological study of pemphigus have been quite unsatisfactory and nothing can be deduced from the results so far attained, for while some investigators have found the blisters and vesicles sterile, others found them to contain streptococci and staphylococci.

The etiology of pemphigus is equally obscure, dermatologists do not

agree in their explanations of the origin of the eruption, and not one certain causal factor is known. As a rule, there is no previous nor exciting history obtainable, the effects of sex and heredity are of little or of no importance, and the ages of the victims vary from infancy to so great an advance as 80 years. The majority of observers believe vasomotor disturbance to be at the root of the affection and that it is therefore due to a trophic neurosis, while certain other observors are inclined to the hypothesis that toxins circulating in the system affect the nerve endings. Lipschütz regards the eruption to be neuropathic, or bacterial or parasitic in origin.

There is no definite course or duration of pemphigus of the conjunctiva, it is, however, usually slow, and extends over a period of years, even for so long as seven years as in a case mentioned by Samelsohn, which was followed by but little or no atrophy of the conjunctiva, although in Silcock's case on the contrary, one eye was completely destroyed and the other seriously damaged in six weeks. In many cases the conjunctival sac becomes in the course of years completely obliterated, and the lids immovably fixed to the eyeballs. The condition usually begins in one eye and involves the other later on; these serious and untoward effects manifest how very different are the results when pemphigus affects the skin and when it involves the mucous membrane.

When pemphigus attacks the conjunctiva the outlook is extremely unfavorable, and the prognosis therefore is gloomy, as the morbid process nearly always progresses until the sight is entirely destroyed. Notwithstanding this, Marcus Gunn reported a case in which the cornea was clear a year after coming under observation, nevertheless recovery is rare, although Bordley reported a case of general pemphigus, which ended fatally, in which the conjunctiva had returned to normal.

Nothing has been discovered to prevent the eruption and but little can be done to stay the progress of the bullæ after they have once appeared. The treatment of pemphigus therefore is chiefly symptomatic. The patient should be placed under the best hygienic surroundings and any determinable causes eliminated. Arsenic has been used for many years past, although Weidler did not find any marked effect from its use, and it has been given in ascending doses, being carried to the fullest physiologic limits, while strychnine and quinine in large doses have been used for their supportive properties. Salvarsan and neosalvarsan have not given results decided enough for judgment to be given as to their efficacy, even in cases where the Wassermann reaction has been positive.

Evacuation of the bullæ on the skin so soon as they form should

be practised, White Cooper having opened the bullæ and applied nitrate of silver. Mild lotions should be used, although some have used sulphate of zinc, oils and milk. Bellecontra believed injections of antidiphtheritic serum checked the progress of the disease. Weidler applied the nitrate of silver and sulphate of copper in stick, and castor oil to relieve the dryness of the surface. High frequency currents and radium have been ineffectual, and the same can be said of the X-rays also.

Operations for the correction of the deformities of the lids are unsatisfactory, but to relieve the effects of the distortions and deformities of the conjunctiva, mucous membrane and skin have been transplanted by Thiersch graftings and other methods. Marple transplanted skin from the inside of the arm near the axilla in a case which remained quiet after four years.

White Cooper (*Royal Lond. Ophth. Hosp. Rept.*, Vol. 1, p. 155, 1858); Pergens (*Pemphigus des Auges*, Berlin, 1901); Weidler (*Jour. Amer. Med. Ass'n.*, Vol. 59, Sept. 21, p. 1016, 1912) are the chief sources of information on the subject. See, also, p. 6761, Vol. IX of this *Encyclopedia*.—(B. C.)

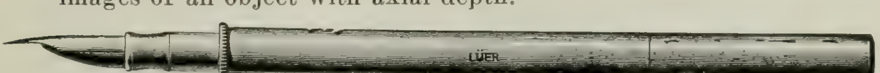
Penciliform. Having the form or appearance of an optical pencil.

Pencil of light. A narrow bundle of rays of light meeting at or diverging from a point; a conic pencil of light-rays.

Pencils. Sticks. Fused cylinders. Points. When it is desirable to apply solid substances to the tissues these are conveniently applied as moulded cylindrical forms, like lead pencils. Good examples are silver nitrate, alum, "lapis divinus," iodic acid and other agents fused and run into moulds. Quite a few remedies, like pyoktanin, are made like the following convenient modified copper sulphate pencils for trachoma and other forms of granular lids into which orthoform enters: ℞ Cupri sulph. pulv., 10.00; Orthoform., 5.00; Holocain. hydrochlor., Tragacanth., āā 4.0; Aquæ dest. q. s.

Mix thoroughly and roll into pencils of convenient size. There are numerous other formulæ made up in this shape.

Penetrating power. The power of an optical system to produce focused images of an object with axial depth.



Nieden's Fountain Pen for Tattooing the Cornea.

Pen for tattooing. Nieden has devised this instrument, made in the shape of a fountain pen, with reservoir and sharp points for tattooing the cornea.

Penicillium. This genus of mould fungi—of which the *Penicillium glaucum* is the best known variety —is occasionally found along the lid edges and may gather as an obstruction in the lachrymal canaliculi.

Pensions for blindness. This subject is discussed as to basic principles on p. 7114, Vol. IX, of this *Encyclopedia*, and will be pursued further under **Visual economics.** See, also, *Pensions* under **Reeducation of the blinded.**

Pentachromic. A color-blind person who is able to distinguish five colors only.

Pentagon. A figure of five sides and angles.

Pentahedron. A solid having five faces.

Pentammon. The second best oculist of Egypt in the 6th century B. C. His one superior was Nebenchari. There is an interesting story about these two men which has been preserved by Herodotus. Cambyses, son of Cyrus, king of Persia, finding that his mother, Kassandane, was blind, sent to Amasis, king of Egypt, beseeching him to dispatch to her aid the greatest of Egyptian oculists, whoever that might be. Amasis sent to her Nebenchari. This oculist, on arriving in Persia, found his royal patient afflicted with senile cataract. For some reasson, however, he hesitated to perform an operation, until one day, happening to learn that his king, Amasis, had also gone blind from the same affection, and that he had been successfully operated on by Nebenchari's great rival, Pentammon, the timorous Nebenchari took heart, operated (by couching) and restored to Kassandane her sight.—(T. H. S.)

Pentangle. A five-angled figure; a pentagon.

Penumbra. The imperfect shadow which surrounds the border of a perfect shadow—as in a lunar or solar eclipse—when the light comes from a luminous surface instead of a point.

Pepper. *Piper nigrum.* Mixed with gall or honey, black pepper was esteemed by numerous physicians of antiquity as a remedy for incipient cataract (hypochyma), amaurosis, and ulcers and scars of the cornea.—(T. H. S.)

Pepper-wort. *Nigella sativa.* BISHOP'S-WORT. ROMAN CORIANDER. A decoction of the bruised plant was regarded, in ancient Greco-Roman times, as a remedy for epiphora.—(T. H. S.)

Perception. This word, in philosophical language may mean *internal* perception, the apprehension of any modification of consciousness; but it usually refers to *external* perception, the recognition of an external object by means of the senses—something more than sensation, and including an element of judgment or the comparing power.

Two great disputes connect themselves with perception, both raised

into prominence by Berkeley. The first is the origin of our judgments of the distances and real magnitudes of visible bodies. Berkeley maintaining, in opposition to the common opinion on the subject, that these were learned by experience, and not known by the mere act of vision. The second question relates to the grounds we have for asserting the existence of an external and material world. Hilbert (*Klin. Monatsbl. f. Augenheilk.*, May, 1914) speaks of *double perception.* By this is meant the production of impressions on the nerves of more than one sense by the stimulas which ordinarily influences one sense organ only. In the past the following forms have been observed: Color and form phenomena in sound perception; sound observance in light or color perception; color and light phenomena in olfactory sensations; color and light phenomena in taste sensations; color, light and form phenomena in pain, temperature and touch perception; color and light phenomena with vision of form.

A photisma consists either of a tinted visual field or part of one, or a shaft of light or colored rays emanating from the object which gives the primary visual stimulas.

The few phonismas which have been observed consisted of a noise having an indefinite consonant note. The double perception is the more intense the less the individual pays attention to it, and the mode of onset is similar in all individuals. The phenomenon is more pronounced in childhood and is to a great degree hereditary. Psychopathic individuals are not any more prone to it than normal persons. The phenomena have been explained in a variety of ways by (1) von Bethe, (2) on Darwinian principles, (3) by Steinbruegge, (4) by Thorp.

Hilbert does not consider any of these theories sound, as a case reported by Lohmann could not be explained by any one of them. After discussing Urbantschitsch's work along this line Hilbert describes his own case: A lady of excellent musical training saw people on foot or horseback in various costumes when listening to most musical renditions. The same individuals with the same surroundings appeared each time a certain selection was played. A voluminous and thorough bibliography is given.

Perfection bifocals. A trade name given to bifocal lenses. See p. 952, Vol. II of this *Encyclopedia.*

Perforation. This word is loosely applied to rupture of the eyeball from an abscess or growing tumor as well as from external injury.

Perhydrol. Hydrogen peroxide. This is a pure solution of hydrogen peroxide (q. v.) in water, containing 30 per cent. by weight and 100 per cent. by volume of H_2O_2. It mixes in all proportions with water and is a powerful antiseptic, deodorant, styptic and germicide. As a

collyrium-germicide it is employed as 0.30 per cent. solution in distilled water. It is strongly recommended as an improvement on the ordinary 3 per cent. solution of peroxide of hydrogen.

Peribrosis. Ulceration or erosion, especially at the angles of the eyelids.

Perichoroidal. Surrounding the choroid.

Perichrista. According to Scribonius Largus (*circa 50 A. D.*) a favorite remedy for ophthalmia neonatorum. Its chief ingredient was saffron.—(T. H. S.)

Pericorneal neurotomy. See **Neurotomy, Pericorneal,** p. 8363, Vol. XI of this *Encyclopedia.*

Peridacryocystitis. Pericystic (lachrymal) abscess. A rather rare condition of infection of the neighborhood of the sac which may end in abscess and discharge but is not connected with the interior of the sac or the *viæ lacrimaliæ.* In this instance the lachrymal canals are generally patent; in true lachrymal abscess they are obstructed. A good account of this subject is given by Aubaret (*Journal de Méd. de Bordeaux*, p. 185, March 24, 1912). See also **Lachrymal diseases** and **Dacryocystitis.**

Peridectomy. Syndectomy. Furnari (*Ann. d'Oculist,* 1863. XLIX, p. 272) was the first to advocate removal of a strip of conjunctiva surrounding the cornea as a means of combating pannus. A broad ring of circumcorneal conjunctiva extending from the cornea to within 3 mm. of the line where the conjunctiva is reflected from the globe to the inner surface of the lid, is dissected up. The subconjunctival tissue is disected to expose the sclera and the vessels of the cornea are scarified. Finally, the sclera and ulcerated cornea are touched with a strong solution of silver nitrate. The indications for this operation as given by Furnari are as follows: (1) In membranous or fleshy pannus. (2) In phlebectasiæ of the conjunctiva or cornea. (3) In simple vascular keratitis. (4) In interlamellar infiltrations of the cornea. (5) In corneal lesions attending entropion, ectropion and trichiasis. (6) In staphyloma of the cornea.

Agnew (quoted by Beard, *Ophthalmic Surgery,* p. 353) practised a similar method, and insisted on a thorough curettage of the episclera surrounding the cornea. The trunks of the corneal vessels were scratched or touched with glowing galvano-cautery where they crossed the limbus. At the dressings the conjunctiva was loosened and pushed back with a blunt instrument.

The operation of peridectomy is thus described by Fox (*Diseases of the Eye,* 1904, p. 122) who has been a most ardent advocate in America of this operation.

"The eyelids are held apart by the speculum and several instillations of cocaine made in order to anesthetize the conjunctiva. A fold of conjunctiva near the cornea is grasped by the fixation forceps and divided by scissors. For partial pannus a band of circumcorneal conjunctiva about 5 mm. wide is dissected on the side of the engorged vessel. If the pannus be general a complete circular zone must be cut away including the subconjunctival tissue to the sclera in order to form a dike of cicatricial tissue against the convergent vessels. In cases of pronounced pannus a circular incision of the corneal blood vessels by means of a Beer knife is necessary. The appearance shortly after the operation of peridectomy is often alarming, inasmuch as the vessels appear to get a fresh start and the pannus becomes thicker than before. The final outcome, however, is satisfactory. Atropia will have to be used to lessen the photophobia and pain."

Falta (loco cit.) cauterizes vascular loops with a galvano-cautery. He declares that curettage of the pannus leads to the formation of dense corneal scars.

Boeckmann advocates the excision of an annulus of conjunctiva followed by vigorous scarification of the subconjunctival and episcleral tissue. The area is then dusted with iodoform. He aims to secure, through the formation of granulations, a scar tissue which will protect the cornea from further invasion of vessels.

Perigee. That point in the moon's orbit which is nearest to the earth.

Perihelion. The point in a planet's orbit at which it is nearest to the sun.

Perimetar. Pertaining to perimetry.

Perimeter. An instrument for determining the limits of the visual fields for white and colors; also for demonstrating the size, site and other characters of scotomata within the area of the field of vision.

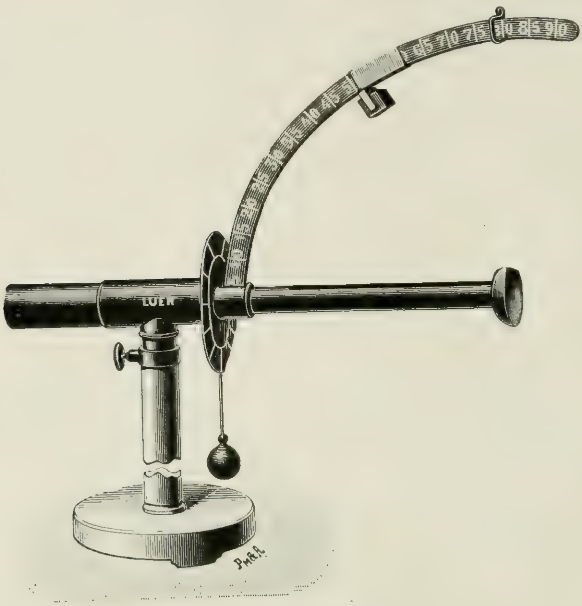
This caption has already been discussed elsewhere in this *Encyclopedia*, notably under **Perimetry** and under such headings as **Color scotoma**; also, on p. 4765, Vol. VI; on p. 3572, Vol. V; on pp. 921, 1003 and 1005, Vol. II; and pp. 5677, 5942, Vol. VIII, of this *Encyclopedia*.

These references by no means exhaust the long list of the instruments and devices for perimetry described in these volumes. Many others are depicted under the names of their inventors—to which the reader is referred. To the matter in these headings other rubrics (in alphabetical order) are now appended.

Aubaret's portable perimeter. For description, see page 4767, Vol. VI of this *Encyclopedia;* also see cut under **Perimetry.**

Badal perimeter. The cut sufficiently indicates the method of using this form of the instrument.

Black's electric perimeter. Nelson M. Black (*Ophthalmic Record,* Mar. 1913) devised an electrically lighted perimeter that promises to be of much value to the ophthalmologist. He states that by taking the field in a dark room there will be but little variation in the width of the pupil. As there will be no attempt at accommodation the position of



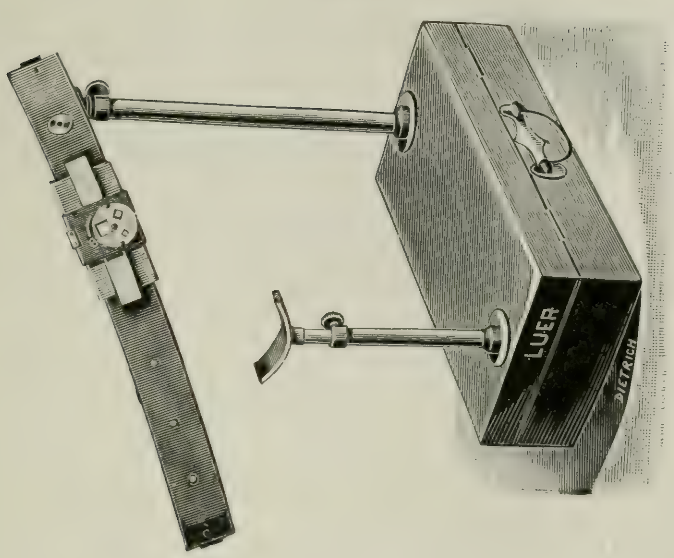
Badal's Perimeter.

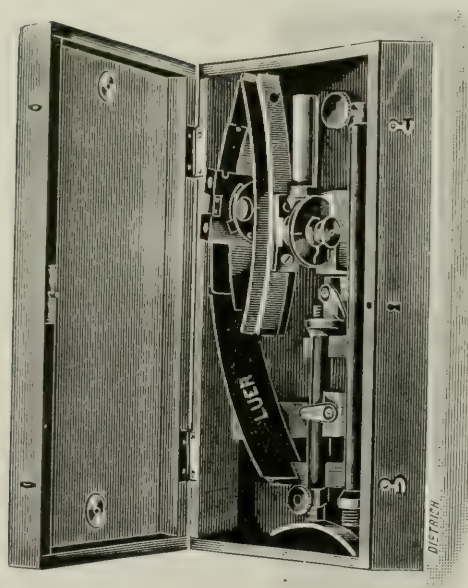
the plane of the iris will remain stationary. The retina will be in a state of greatest sensitiveness to light stimulation because of its dark adaptation and by taking a field in the dark there is nothing to distract the patient's attention. The perimeter is designed after the latest model of the McHardy instrument.

Bordeaux's perimeter. As shown by the cuts, this campimeter may be easily carried about and is for that reason valuable for house visits and in hospital ward examinations. The movable chin-rest, the arc, wide enough to cover the hand of the examiner in moving the carrier from 90° to zero, the arrangement of the carrier for a ready change in the size and color of the test objects and duplication of the latter at the back, so as to be seen by the observer, make this instrument a valuable aid to diagnosis.

Bouchart's fan. See *de Wecker's perimeter*, under this heading.

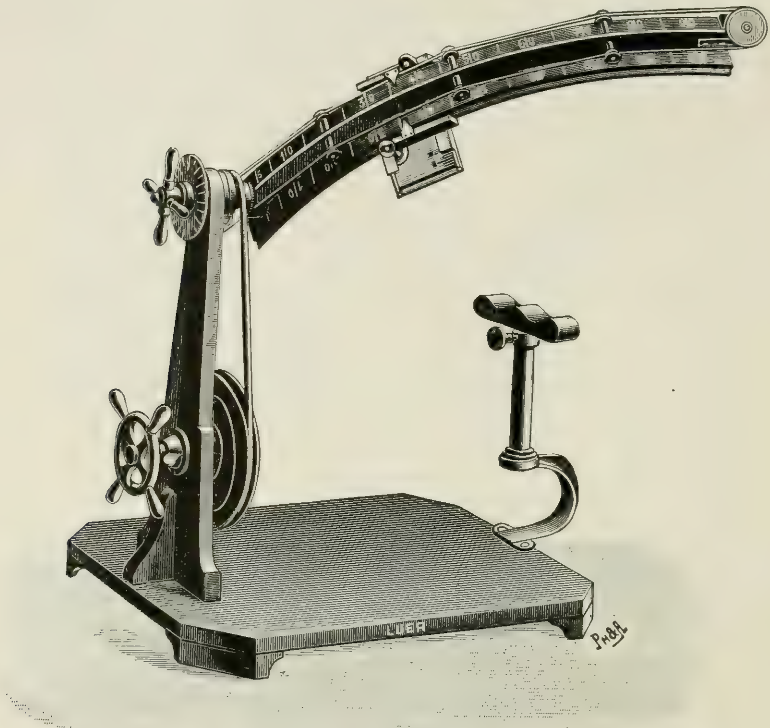
De Lapersonne perimeter. The cut shows the method of moving





Bordeaux's Perimeter.

the arc and its mires. The instrument is not as handy as the British or American models or variants of the McHardy instruments.



De Lapersonne's Perimeter.

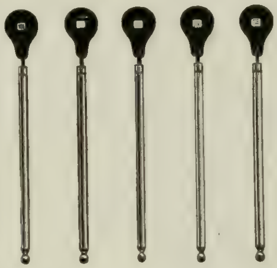
de Wecker's perimeter. This simple device is sufficiently explained by the illustration. (For cut see section on **Perimetry,** infra.) The ribs of the (Bouchart) fan hold six colors (red, blue, green, yellow, white and gray) of round test objects representing respectively 5, 25, 50 and 100 square mm. of surface. These mires are moved along the surface of the small blackboard.

Förster's perimeter. This instrument (see the cut under the heading **Perimetry,** herein) much resembles in construction and application the well-known McHardy perimeter, described on p. 4768, Vol. VI of this *Encyclopedia.*

Löw's self-registering perimeter. The objection to this device is its complicated machinery and the probability of its getting easily out of order—as contrasted with the McHardy instrument, for instance.

Maddox hat-pin perimeter. As E. Maddox (*Ophthal. Rec.,* June,

1915) points out, a white-headed hatpin makes an excellent test object, but as used at present, the movement of the hand which holds it is also visible and may defeat anything like a quantitative test. The little cylinder of wood, cork or rubber tube about half an inch long and of the thickness of a lead pencil (in which the point of the pin is inserted) held between the finger and thumb enables the hand to be kept perfectly stationary and yet allows the head of the pin to make consider-



Hand Perimeter. (Hird.)
For description see p. 5942, Vol. VIII of this *Encyclopedia.*

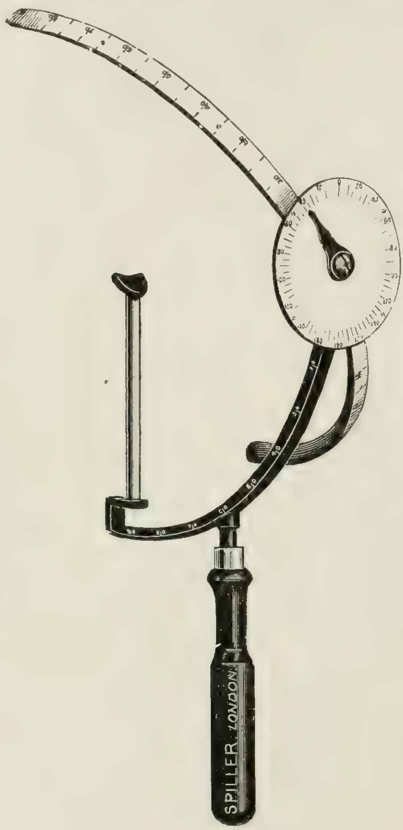
able excursions with an almost insensible movement of the thumb and forefinger.

Reitsch's perimeter. This device is described in the *Klin. Monatsbl. f. Augenheilk.,* Jan., 1913.

If a patient is seated at the perimeter as if for the measurement of the field of vision, and if the eye which is in position is examined by indirect ophthalmoscopy, it is possible for the observer to define the position of any lesion in the fundus by the use of the arc of the perimeter. Two figures giving the meridian of the lesion and its distance from the fixation point will sufficiently indicate the position which it occupies in the fundus. There are, however, a number of sources of error when this simple method is used. The examiner fixes his ophthalmoscope in one of these notches. For the fixation a second upright supporting rod is placed to one side of the middle upright. The two upright supports can be adjusted according to the distance between the two eyes and so revolved that they can be used on either eye of the person to be examined. To prevent raising or lowering of the patient's eye, a fixation mark is placed at the turning point of the perimeter. This fixation mark can be advanced or receded. A supplementary dial, attached to the rod which fixes the patient's eye, enables one to mark out on the eyeball the meridian in which the foreign body is located.

Schiötz self-registering perimeter. The inventor (*Norsk Magazine for Laegevidenskaben,* September, 1915) describes a new apparatus

similar to the one proposed by him in 1885. In the new perimeter the chart is in a fixed position, and the recording apparatus movable, whereas in the earlier perimeter the reverse was the case, so that the chart was liable to become misplaced. The most important difference between the two perimeters is that the arc is now made with a radius



The "New" Hand-Perimeter. (Spiller.)

of thrity-three centimeters, instead of twenty-five centimeters, as formerly; that the width of the arc is six centimeters as against two centimeters; and that the central disc to which the arc is attached now measures twenty centimeters in diameter, as against ten centimeters formerly. The test objects are one, two, three, five and ten millimeters in diameter, and are secured at the end of a thin, stiff, black metal rod.

Spiller's new hand-perimeter. It is constructed of gun-metal, and the section used is such as to give great strength without undue weight. The seating on which the arc rotates is accurately machined and rotates

quite smoothly and easily, and the handle is fixed in such a position that the instrument is nicely balanced when held vertical. The scales are all engraved on white celluloid with large black figures which cannot be mistaken, and the dial is larger than usual giving wider divisions, the latter being a great help to the accuracy and rapidity of use. The five (5) targets are permanently fixed on handles, thus doing away with the troublesome fixing of each different target in a holder, which distracts the patient. Each target has on one side a 10 mm. square, on the other a 5 mm. square. The colors are white, red, blue, green and yellow. See the figure.

Universal Registering Perimeter.

Universal perimeter. The American model is said by the proprietors to fill the demand for a high grade instrument at a small cost.

This instrument combines the most practical points of the Landolt and Priestley-Smith perimeters. It is light and well-balanced and has the broad, metal arc, with the sliding object carrrier of the Landolt and the registering attachment of the Priestley-Smith. It has a reversible chin-rest, sliding upon the upright bar, the end of which carries a rubber plate and determines the point of fixation.

The chart is fitted to a hard rubber disk at the back of the instrument, and is revolved with the arc. A stationary scale, mounted upon the upright arm, is graduated to correspond to the divisions of the arc and the exact position of the object point upon the arc and the meridian of the arc itself may be pricked upon the chart by a single puncture.

The graduations on the arc are in two distinct colors, and the stationary registering scale is divided and colored in a similar manner, so that it requires a simple observance of the color in pricking the chart. As the chart rotates simultaneously with the arc, all possible error from lost motion and liability to get out of order through complicated gearing is obviated.

Five color disks in 5mm. and one white disk in 10mm. are provided. These are held by the object carrier or on the handle furnished, which can be used as an auxiliary hand perimeter.

Von Michel's electric perimeter. Collin (*Zeitschr. f. Augenheilk,* p. 305, 1906) discusses the insufficiency of perimetric tests with small colored objects and of Holmgren's skeins, as both may yield opposite results in the same case. For clinical diagnosis only such methods are admissible which allow of separate testing of central and peripheral color perceptions. This is obtained by means of the electric perimeter of von Michel. The test objects, illuminated by an electric lamp, consist of two round, rotable discs. The lower contains five glasses of different colors (green, yellow, red, blue, white), as much saturated as possible by combination of a number of differently colored glasses, and equivalent as to light adaptation. The upper disc has six square-shaped holes with sides of 1, 2, 5, 10, 15, 30 mm. length, in order to change the sizes of the underlying colored fields. An exclusively focal fixation is insured by setting the carrier with the square of 4 mm. on the point of fixation of the perimeter, a small plate of ivory. For ascertaining the peripheral borders the areas of 100 mm. are recommended. The color of the perimeter itself is gray, not black, to secure a neutral background and to avoid contrasts.

Perimetry. Measurement of the field of vision. Although many of the following subtitles have been to a greater or less extent discussed in this *Encyclopedia* it is felt that, even at the risk of some repetition, it is in the interest of the student to bring together under one heading the main observations that have, especially during the past forty years, been made in this domain of ophthalmology.

In addition to a number of other minor captions related to this subject the attention of the reader is especially directed to p. 4765, Vol. VI, and to p. 3572, Vol. V of this *Encyclopedia;* also to the headings **Haitz campimeter**; to **Bjerrum's method of perimetry** and to **Blackboard perimeter.** See, also, **Military surgery of the eye**; as well as **Hemiopia**, p. 5766, Vol. VIII of this *Encyclopedia.*

The whole subject as treated in this section is divided into:

I. The Nature and Extent of the Field of Vision. II. Methods

Employed for the Examination of the Visual Field. III. Nomenclature, Contour and Position of Changes in the Field of Vision. IV. The Visual Field in Various Diseases of the Eye. V. The Field of Vision in Cerebral Tumor and Other Brain Lesions. VI. The Visual Field in Functional Nervous Diseases. VII. The Visual Field in Systemic Diseases.

A CONSIDERATION OF THE NATURE AND EXTENT OF THE VISUAL FIELD.

(A) *General considerations.* The visual field is the total expression of the functional activity of the percipient portions of the organ of sight in fixation, projected outward into infinite space. Concisely

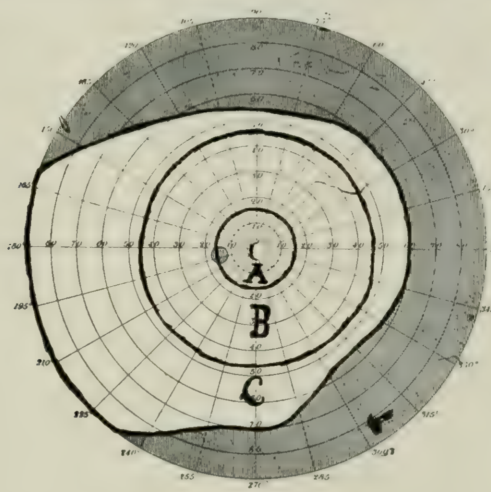


Fig. 1.
Showing the Three Zones of a Normal Visual Field. A. central, B. intermediate, C. peripheral.

expressed, it is the extent of vision, in all directions, while the eye is directed at a fixed object.

Within this field of vision we have a central area of acute sight, in contrast to its eccentric areas, which are those of less acute vision. That portion of the visual field of a normal eye where vision is most acute, we speak of as the region of *direct,* or *central vision,* in contrast with its expressions in the outer portions of the field, which we designate as the areas of *indirect,* or *peripheral vision.*

Visual acuity, direct, central or *qualitative* vision, is the expression of that region of the retina known as the fovea centralis. Indirect, peripheral, or *quantitative* vision, is the expression of the remaining

portions of the retina which lie external to the macula, or beyond the points at which visual acuity, or qualitative vision crosses into the region of indirect, or quantitative vision. This change occurs quite abruptly at a region near the borders of the fovea. Beyond this region visual acuity declines rapidly. Königshöfer states, that at 1° outside of the foveal area vision becomes suddenly reduced to about $\frac{1}{3}$ as compared with the acute vision in the center of this region, and he states moreover, that at 2°, or 3°, distant, it is still more greatly reduced to about $\frac{1}{6}$.

In a discussion of the visual field, central visual acuity,—as the field expression of the function of the macular region is called,—must, necessarily, be considered, although, not infrequently, the term "visual field" is carelessly used to designate only those parts of the field external to the point of fixation, which parts represent the functional activity of the peripheral zones of the retina alone.

The field of vision should not be confounded with the field of fixation. By the latter (Fig. 2) we mean the extent in all directions toward which the eye may be directed, *while the head* is firmly fixed, while by the field of vision we understand that space perceived *while the eye* is fixed. The limits of the field of fixation are approximately 47° in every direction, and, while not differing widely in their extent from the field of vision in the nasal, superior and inferior directions, yet differ widely from it in the direction of the temporal side.

Since the visual field is inverted upon the retina, the images of objects, resting in the upper visual field, fall on the lower half of the retina, and images, resting in the lower visual field, fall upon the upper half of the retina. Likewise, objects on the right half of the visual field fall upon the left half of the retina, and objects upon the left half of the field fall upon the right half of the retina. Since the retina is functionally active, although in a gradually lessening degree, up to the ora serrata, it may be observed, that, were the eye ball sufficiently protruded from its orbit, its visual field, if projected on a flat surface, would be in the form of a circle the center of which—the point of fixation—would be the projection of the foveal region.

Vertically the visual field of one eye takes in about 125°, and horizontally it includes about 150°. When both eyes are used, the combined field is increased horizontally to 180°, or possibly more. The part of the field common to both eyes is roughly a circle of about 90°. For convenience of study, as well as for reference clinically, we may divide the field into three zones. These are: 1st—The central zone, 2nd—The intermediate zone, and 3rd—The peripheral zone. (See Fig. 1.)

The central zone extends from the point of fixation outward 15° in all directions; the intermediate zone (B) extends likewise outward from the outer limit of the central zone to the 45° circle, and the peripheral zone (C) extends from this point outward to the limits of the field. It is well for us in studying the different zones in the field of vision to remember that they correspond accurately to like zones in the retina, for as in a given area the cones in the retina are greater, or less, in number so is the visual acuity of these retinal zones, as expressed in the visual field, greater or less.

Abney (*Tyndall Lectures before the Royal Institute,* 1894) well pictures the relation of the visual field chart to the retina, in this way: "The concentric circles of the chart are supposed to be circles lying on the retina, corresponding to parallels of latitude on a globe, and are not, therefore, equidistant when seen in projection. To make these circles it must be imagined that we have a bowl, in the middle of which is a thin rod standing upright and passing through the center, and another rod attached to it at the center of the sphere of exactly the length of the radius. If this last arm be opened to make an angle of 5° with the fixed rod, and be twisted round like the leg of a compass against the bowl, it will make a circle, the projection of which will give the innermost circle of the diagram; if opened to 10° it will give the next circle, and so on for every subsequent 10°. The lines passing through the center are 30° from one another, the line stretching from 360° to 180° being a line supposed to be vertical." We shall speak shortly of the method by which the visual acuity of each of these zones may be tested and compared, but, before doing so, let us have, and hold, clearly in mind, the reason for this difference of visual acuity, in the different retinal portions.

There is a marked difference in the distinctness with which objects are preserved as we go from the center of the field outward toward the periphery. Turning to the retina we perceive that the nearer we approach the fovea the more numerous become the cones and the fewer the rods. In other words, the cones predominate, in, and about, the macula, and diminish toward the periphery, while the rods predominate in the intermediate and peripheral zones, and diminish centrally. The total number of cones in the retina is estimated at 3,000,000 of which about 7,000 are in the small fovea alone. The projection of this area of the retina along the visual line is called the *point of fixation*. Now, it is only at, or near, this point in the field that all vision is truly acute, and as the average diameter of the fovea is given as between 0.3 and 0.4 mm., lines drawn from the extremes of these diameters through the nodal points subtend an angle of 1° to

1.5°, therefore, this point, or area of fixation in the field,—that is, the area of most acute vision—is compressed within this limit. Furthermore, the thickness of the retina is much reduced in this region of the fovea—this, in fact, causes the depression—so that the cones are practically exposed directly to the light, whereas in the intermediate and peripheral zones, the light waves must penetrate through the retinal layers before striking the rods and cones. Many facts unite to indicate a different function of the rods and cones—which differ in structure as well as in their histologic connection—as the conduction paths of the cones are seemingly more direct than those of the rods, and furthermore the latter elements possess the visual purple, which

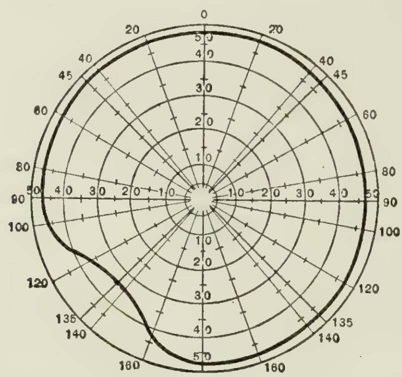


Fig. 2.
Normal Field of Fixation of a Right Eye. (Landolt.)

is lacking in the cones of the totally color-blind, in the color-blind periphery of the visual field, as well as in the eyes of night-seeing animals, such as the mole, and the owl, whose vision seems to be affected solely by the rods.

Parinaud, von Kries (*Zeitschrift. f. Psych. u. Physiol. d. Sinnesorgane*, 1895) and others, believe the color function rests with the cones. The function of distinguishing between light and darkness with the rods, and also, that they form the special apparatus for vision in dim lights (night-vision).

The significance of the different visual values we must attach to the different zones in the field causes the writer to interject this consideration of the rods and cones, for it is only by an understanding of their position and function that we could be brought to a proper appreciation of the nature and significance of the normal visual field, which is but an outward expression of the retina through its contained rods and cones.

The perceptible retinal image, or what is known as the *physiological point,* is the size of a just perceptible image on the retina, and Guillery (*Zeitschrift f. Psych. u. Physiol. d. Sinnesorgane,* 1896) in order to determine the size of this point, used a small black spot on a white background. At a distance this was invisible, but when brought nearer was perceived. The size of the spot being known, as well as the distance, when first perceived, the size of the retinal image could be quickly ascertained. This physiological point Guillery found to be 0.0035 mm. This estimate relates only to the fovea, and, indeed, only to its center, the foveola. Attention has been called to the fact that the size of the point varies with the degree of illumination. The estimate given by Guillery was made in ordinary daylight, and with bright illumination, but with patients living habitually an outdoor life, this physiological point is much smaller—perhaps less than half the size given by Guillery. Thus it will be observed that, at the fovea, we may perceive an object of less than the diameter of a single cone, that is, 0.002 mm.

As already noted under the investigations of Königshöfer the visual acuity diminishes very rapidly as we leave the foveal region, so that we find the form-sense less developed in the outer parts of the central zone, still less so in the intermediate zone, and least of all in the peripheral zone. For color this is more pronounced, at least it is so under the conditions we use commonly in our clinical work to define it. For example at 20° from the foveal center the physiological point on the retina is 0.035; in other words it has a diameter of ten times the size of the point in the fovea. For this reason objects eccentrically observed are much less distinct, being spread over a greater number of retinal elements, and the *details* of form are therefore lost, or confused, or are indistinct. This is a wise provision, since were it otherwise, and the entire field of vision of equal acuity, there would result much cerebral, and visual confusion.

In this general consideration of the field, the relation of its different zones, or parts, to their related parts of the retina is necessary in order that a clearer understanding of the visual value of the different zones of the field might be well understood.

The visual acuity of each of these three zones may be tested, and the differences noted. This test may be made with the ordinary perimeter, the test object, in this case, being composed of two black squares, separated from each other by a space equal to their own length. As a control, have the patients answer as to whether, or not, at different parts of the field these two squares are seen as two distinct objects. A black rectangular figure of the same breadth, but three

times the length of one of the squares, is alternately placed in the same position. For convenience the two figures may be placed on the two sides of a piece of cardboard, or the one on the one side, the other on the other, respectively. The visual acuity of the observer is the standard used to control the test. It will be quickly observed that the visual acuity is much sharper in the central zone, less so in the intermediate zone, and least so in the peripheral zone, thus coinciding with, and clinically confirming, the anatomical findings regarding the cone distribution throughout the retina.

The zonular difference in the visual acuity is, as well, observed in the differences to be noted in the reaction of the different zones to light intensity, and its closely related reaction to color perception. The function decreasing in all cases as we pass from the center to the periphery.

The extent of the field forwards is into infinite space, it being, virtually, of an irregular cone shape, whose base increases in extent directly as its distance from the eye. Its normal lateral extensions vary in different individuals, and occasionally even in the same individual when more than one test is made, due to circumstances which will be later explained.

We have, so far, considered those portions of the field of vision apart from its central area. In the central portion of the field, we find the fixation point, or center of the field, and the blind spot of Mariotte. The optic disc, which lies about 15° to the nasal side of the fovea, has no retina over it, and has a diameter of about 1.5 mm. Light that falls upon this area of the fundus is not perceived, and gives rise to the so-called blind spot of Mariotte in the field of vision.

Normally, the blind spot of Mariotte is an oblong space with rounded corners, lying a little to the right or to the left of the fixation point. The rounding of the angles varies in different individuals, and the vertical length has to the horizontal breadth the proportion of six to four. About one-third of the whole space is above a horizontal line drawn through the fixation point. A narrow zone of relative or transitional amblyopia for white surrounds the area of absolute blindness. and outside this is the limit of the absolute scotoma for blue, then that for yellow, then that for red, and last of all that for green, the order being the same as that which obtains at the peripheral part of the visual field, there seeming to be a zone of transitional amblyopia for all the colors. The absolute blind area for green is relatively very large and its inner boundary almost reaches the point of central fixation.

We do not notice this blind spot of Mariotte in the field of vision,

as it is not in the field of direct, but in the field of indirect vision, and furthermore, for the reason that in binocular vision, that portion of the external world which falls upon the optic disc of one eye falls on a perceptive area of the retina of the other eye. Therefore, in each eye, about 15° to the outside of, and 3° below, the fixation point is a physiological scotoma, which lies in the area described, which is usually represented on the chart between the tenth and twentieth concentric circles.

This interval, according to Landolt, is greater in hyperopes than in myopes. For the detection of the blind spot, and changes about it of pathological significance, the test proposed by Bierrum (later described) is valuable. Helmholtz accords the shape of the blind spot that of an irregular ellipse. Landolt and Babrowlsky have determined the distance between the macular lutea and the disc in emmetrops to be 3.915 mm. In moderate hyperopia this distance is somewhat greater, and in moderate myopia somewhat less.

Ovio calls attention to the fact that the blind spot appears much larger when measured with a light test object than a dark one. This may be explained by irradiation, and, also by the effects of spherical aberration and other departures from accurate focusing of light upon this part of the retina. Polaminto also writes upon the physiology of the blind spot of Mariotte.

Congenital medullated nerve fibres running to a greater or less degree into the retina may cause enlargement of the blind spot.

Van der Hoeve (*Arch. f. Augenheilk.*, Vol. LXX, No. 2, 1911. Translated in the *Archives of Ophthalmology*, July, 1912) appreciating the importance of early recognition of the enlargement of the blind spot in the diagnosis of disease of the accessory nasal sinuses, undertook to accurately determine the size of the blind spot, and also its distance from the point of fixation in the emmetropic eye. Measurements were made upon 100 practically emmetropic eyes. The tests were made upon a black surface two meters distant, and dice, with colored circles 1.5 to 1 cm., were used as test objects. The results showed that 100 practically normal eyes possessed a blind spot whose center, in the horizontal direction, was situated 15° 33′ 47″ from the point of fixation; in the vertical direction, 1° 40′ 41″ below. The horizontal diameter measures 5° 42′ 55″; the vertical diameter, 7° 26′, and that it is surrounded by a zone relatively blind for white, ⅛° to ¼°, and a zone relatively blind for colors ⅛° to ¾°.

Computed according to Landolt the horizontal distance, from the middle of the fovea to the middle point of the blind spot, is 4.0245 mm.; vertical 0.4425 mm.; disc diameter, 1.6125 mm.; disc height,

2.025 mm. These 100 eyes belonged to persons between 18 and 22. The author states that in his opinion a horizontal diameter of the blind spot of 7° is too large, and one over 6° is suspicious and should require further investigation. He also thinks that a relative color scotoma of more than 1° is suspicious.

(*B*) *The form field.* For the light field—used synonymously with the form field—Förster (*Klin. Monat. f. Aug.*, 1853) proposed as a result of his investigation for the outer field limit 90°, for the upper limit 55°, for the inner limit 60°, and for the lower limit 70°. Haab later (1893) gave 70° for the outward, 40° for the upper, 45° for the inner, and 65° for the under limits of the field.

Von Reuss (*Das Gesichtsfeld bei Functionellen Nervenleiden*) holds the field of Förster too great, and that proposed by Haab too small. Baas gives 99° outward, 65° upwards, 63° inwards, and 75° downwards. De Schweinitz gives the limits of the field as outwards 90°, upwards 50°, inwards 60°, and downwards 72°.

The very marked variation in results obtained by such authorities is not altogether surprising when viewed in the light of the different means employed to obtain these results. For example, the sight test marks employed by von Reuss were 1 cm. square, those used by Baas were 2 cm. square while de Schweinitz used 1½ cm. objects. Moreover much depends, in defining the boundaries of the field, upon whether we have the patient indicate the appearance of the object when he receives the first visual impulse of *an object* only, or, on the other hand, when he receives the actual definite visual sensation of a clear white, or—if testing for the color fields—of a pure color sensation. The latter sensation is, manifestly, somewhat later than the former, and the field, taken under this test, will be narrower than by the former—i. e., by the mere sensation of the object. Furthermore, the writer wishes to speak of a factor in making the test, that, too often, may cause varying results. He refers to the quickness, or the slowness, of the patient in making known his sensations of the object. When the test is repeated very often the patient will answer some degrees on the arc ahead of the first test, provided we are not dealing with a case of retinal fatigue. Mental inertia, in some patients, is so marked as to establish a wide limit between the field obtained and, what may be called, the possible field. In order to obviate, to the fullest possible extent, the error which may creep in as a result of this, the writer has for some time had the patient hold his finger on a small touch bell, and warned to immediately press the plunger of the bell upon the first appearance of the white color of the test object.

To obtain a normal standard von Reuss examined with the peri-

meter the eyes of ten more than usually intelligent persons. He found the outer field ranged from 80° to 90°, the upper field from 48° to 70°. the inner field from 53° to 63°, and the lower field from 65° to 70°. It becomes very proper to ask, in view of the highly different figures given, "when, then, is the visual field contracted?" When it is smaller than it was in the former healthy individual, or when it is smaller than the smallest field of a normal individual? As von Reuss points out, it is seldom we are permitted to take a field of one suffering from nerve trouble, where the field has been measured before the onset of visual trouble. An apparently normal field (measured by accepted standards) may, by the onset of disease, be smaller than the previously existing field, and thus the so-called normal field found—being a contraction of its former field—may be, in very truth, abnormal.

For example: A patient with a central visual acuity of 6/6, who formerly possessed 6/4, has a diminished, and for this patient, an abnormal sharpness of vision.

We must, however, from a large series of fields, accept the average of the smallest fields of healthy individuals as the standard from which we are to judge where the abnormal begins.

The figures given by Förster for the four principal meridians of such a field are those commonly accepted, and are, as stated, for the outward field 90°, for the upward field 55°, for the inward field 60°, and for the downward field 70°. This field is taken with 5 mm. square test objects.

The field described is known as the *relative field*, being the field obtained when the eye is fixed at the pivot point of the perimeter, and with the interposed barriers, as the nose, etc., already described. In contrast to this field Mauthner, by attaching a piece of white wax to one arm of the perimeter at 30° from its center, and with the head in the usual position, and the eye fixing to the eccentric fixation point, measured the full extent of the field by passing the test object along the opposite arm of the perimeter. By testing in this way Mauthner found a "*maximum field*," as represented in figure 3, the outer line of the gray border, in the figure, representing the limits of the maximum form field, and its inner line the limits of the usually accepted field obtained when the individual fixes the center of the perimetric chart. In contrast to the relative field, that is, the field whose dimensions we accept as 90—55—60—70 this field of 100—65—60—77 is known as the *absolute* field.

The extent of any obtained field depends, not wholly, but in a large measure, upon the size of the visual angle formed by the object used in testing the field, as well as the distance of the eye from the plane

of the test object. The maximum field obtained by central perimetric fixation—the generally accepted normal field—is only obtained from test objects that afford a visual angle of ½° or more. Test objects affording a smaller visual angle give correspondingly smaller fields. The test objects usually employed give a visual angle of from 2° to 4°. The images of such test objects must cover a larger area of retinal elements, and thus, compared with tests where smaller test objects are used, give results far less exact. By the use of small test objects, and by placing the patient farther away Bjerrum (see Sec. 4) has obtained information of very exact diagnostic importance.

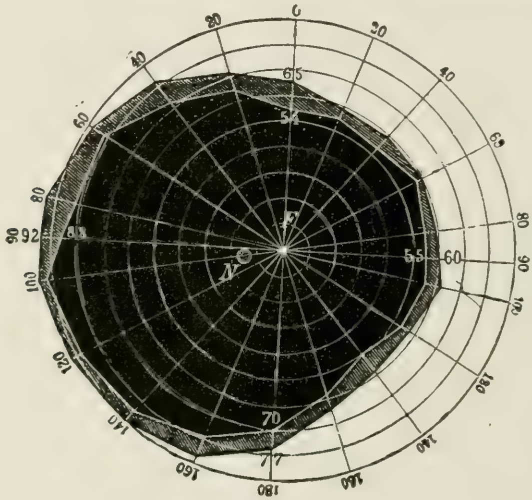


Fig. 3.
Mauthner's Maximum Field.

These final tests by the smaller test objects are of a special value in charting the region about the blind spot. At a distance of two meters the projected blind spot is 7 inches in diameter instead of about 1 inch when taken at 30 cm. on the perimeter, and the rest of the field is increased in size and detail in proportion. With a test object of 10 mm. and testing at 30 cm., the visual angle is 10/300, or approximately 2°, while with the test object of 3 mm. in diameter at a distance of 2 meters, the angle is 3/2000, or about 5′.

With the former test using 10 mm. test objects the usually accepted limits of 90°—55°—60°—70° are obtained for the field, while in the latter case, with the 3 mm. test objects at two meters, the field so obtained is outward 35°, upward 25°, inward 30° and downwards 38°. So long as there is no absolute standardization the latter method with

smaller objects must only be of accepted value for demonstrating the area about the blind spot, and in the central, and parts of the intermediate, zone. For the study of concentric contractions we use the larger test objects on the perimeter with their resulting limits as the index for our judgment.

The size of the object is not alone a factor in the difference in results obtained, for, among causes apart from the eye itself, we find that the degree of brightness of the test object, and the general illumination of the room about this object, have much influence. Besides the brightness of the object, closely associated with it is the effect of the general illumination surrounding the patient, on the pupillary reflexes, with its consequent change of the plane of the pupil, and position of the nodal point of the eye.

The matter of illumination of the test object is, as we shall see later, of prime importance in the defining of the form, and especially of the color, field, which latter, owing to frequent color confusion, will cause, not infrequently, unreliability. The greater the surrounding light intensity—if not directed upon the pupil—and also the greater brightness of the test object, the earlier and more forceful will be the retinal image received, and consequently the wider the color field.

It must here be noted that the field limits in a normal eye, taken with a 5mm. test object in a darkened room, will still remain normal. Hence it is of no importance if these limits be taken in the usual daylight with a gray test object, or with a white test object in a room so darkened that the brightness equals the gray. This is quite otherwise with the placing of the color limits, for if taken in a subdued light the fields are smaller than in a brighter light.

Again, Lievin (*Inaugural address at Königsberg*, 1877) states that a greater field of vision is obtained if the trial object is moved from the center toward the periphery than if it is moved from the periphery toward the center.

As stated, the limits of Förster are considered quite generally well accepted, but that absolute standardization of test objects and of illumination is needed throughout for obtaining results that may be of definite value, cannot be doubted.

Entirely apart from the eyes, and the factors spoken of, including the personality of the patient, is the question of the personal element introduced by the medical examiner himself. The writer has, through the generosity of some of his colleagues, had his own visual fields taken in order to observe to what degree these tests would vary. He has good color perception, and has endeavored to exercise, during the different tests, the same degree of alertness. It is interesting to note

the variation in results. These tests were not made within short periods of each other, so that fatigue could have played no part. However the results may vary in figures, we observe that the normal visual field thus obtained, in all cases, is not circular, but represents the base of an irregular cone greater in its outer and lower portions, and smaller in its inner and upper portions, the size of the projection being dependent, of course, upon the distance from the eye that it is described.

Some of the factors causing the difference in the length of the different meridians of the field of vision are to be noted; first, as Landolt

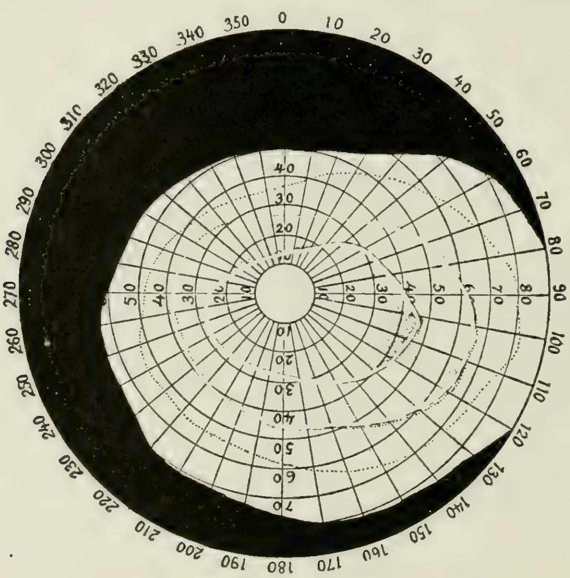


Fig. 4.
Average Field for Blue, Red and Green of a Normal Right Eye.

and others have pointed out, the outer part of the retina is less used than the inner part and its function thereby naturally less developed. It is to be remembered also that the degree of acuteness of vision of the periphery of the retina is lower, it not being anatomically constructed for seeing distinctly, but simply possessing the function of contrasting points and surfaces with their surroundings.

(*C*) *The color field.* The periphery of the retina is that zone usually designated by its position outside of the color field—at that point where the perception of small, blue, test objects ceases. Not only are the retinal visual elements, lying in the zone outside of the line giving us the relative field, less highly organized, but the fact that the farther an object is carried from the fixation point to the periphery

its light is less and less well reflected to the retina, also helps to explain the diminished perceptibility of the retinal periphery. This relation between the amount of light and the color perception, explains, in part, the difficulty at certain zones in distinguishing between certain colors.

The three senses possessed by the retina, those of light, of form, and of color, are each expressed in the field, but in a varying degree. When we examine the peripheral field of a normal eye, we find that in its extreme periphery the retina itself is totally color-blind, perceiving only light and darkness, that is to say, only shades of gray. Passing toward the center of the retina, the color-sense gradually manifests itself, blue colors being perceived first, and the green colors last, so that in a normal eye we find a certain portion that is red-green blind. The color field is mapped in the same way as the field for form, or white, and the colors are recognized from the periphery toward the center in the following order: blue, yellow, orange, red, green, violet. Clinically we use only blue, red, and green colors to obtain the corresponding color fields, red and green being the color senses most affected in diseases affecting the fields.

The accompanying illustration (Fig. 4) shows the average and relative extent of the fields for the three principal colors. Roughly speaking each field is about 10° larger than that field which is next smaller to it in size, that is, the blue field is 10° larger than the red field, and the red 10° larger than the green. The lack of certainty and fixity in the expressions of a color-sense outward into the color-fields can be well illustrated in the following tables which have been prepared to show the different results of Ball and de Schweinitz, well known American writers. In the hyphenated figures those preceding the hyphens are Ball's.

	Blue	Red	Green
Outward	80—80	65—65	50—50
Upward	40—40	35—33	30—27
Inward	55—45	50—30	40—25
Downward	60—75	45—55	35—45

These figures do not differ much more widely than those of many other investigators, when the figures of these investigators are compared.

The fact is, as pointed out by von Reuss, the normal boundaries of the color fields are not definitely determined since they are so very different in different individuals.

The following table has been prepared from investigations undertaken by Baas, with the object of determining the color limits in the field, which in turn were the average figures of eight careful ophthalmologists, after taking a considerable number of eyes for examination. This table is as follows:

	Upwards	Outwards	Downwards	Inwards
Blue	45	84	62	50
Red	39	75	50	39
Green	34	65	43	33

In these investigations Hegg found the limits for green and red identical, while Drott found the field for green even larger than that for red. While the retinal periphery has a color-blind zone, yet with a sufficiently increased light intensity it disappears and the fields for form and color may become identical. However, in clinical practice, color objects of a standardized intensity bring out these different color zones in the retina, that express themselves as the larger blue, small red, and still smaller green fields.

In an effort to define the limits of the color field the experiments of von Reuss are interesting, and his figures are rearranged so that comparisons may be made with Baas' table already quoted. Von Reuss took persons between the ages of twenty and thirty; being doctors, students and painters, and others of like standard. The tests were made under most careful standard conditions. The following table shows the average fields for the colors taken in four meridians.

	Upwards	Outwards	Downwards	Inwards
Blue	34.2	66.2	48.2	44.7
Red	25.9	59.	28.1	29.7
Green	19.7	36.2	22.0	22.9

These fields are much, in fact very much, smaller than those collaborated by Baas.

The extremes of twenty eyes (those of ten persons) under examination were as follows:

Blue	temporal	78—50	superior	48—28
	nasal	52—33	inferior	60—32
Red	temporal	72—40	superior	45—18
	nasal	50—18	inferior	50—20
Green	temporal	60—20	superior	32—12
	nasal	40—15	inferior	42—10

When one compares the results of different observers, and the results of the same observer upon different individuals, as well as the result of different observers on the same individual, relating to the various color fields, it is, indeed, confusing, and one hastens to inquire "what, then, really are to be the accepted boundaries of the color fields?" Some normal fields for green and red are so small that they are still smaller than reasonably assured pathological fields for these colors. The figure herewith represents the average results of investigators, and indicates what may be perhaps considered the normal color field to be used simply for a working hypothesis. The great diversity of these results may be found in several factors, among them the difference in saturation, that is, the freedom of the different test colors from white. Again the luminosity or brightness, as well as the size of the color object, will affect the results, which also in some measure holds true when the white field is taken.

Furthermore, the personal equation of the patient, as well as the personal equation of the investigators, affect the results, and in this connection the application of different methods to obtain the mark on the perimeter that indicates the first appearance of the color to the patient, offers some explanation of the diversity. (See methods of testing, Sec. II.)

In forming a judgment, a comparison of fields of the same case formerly taken is of worth.

We may have the field of vision for red and green, in some rare cases, larger than the field for white. We may have the field for green

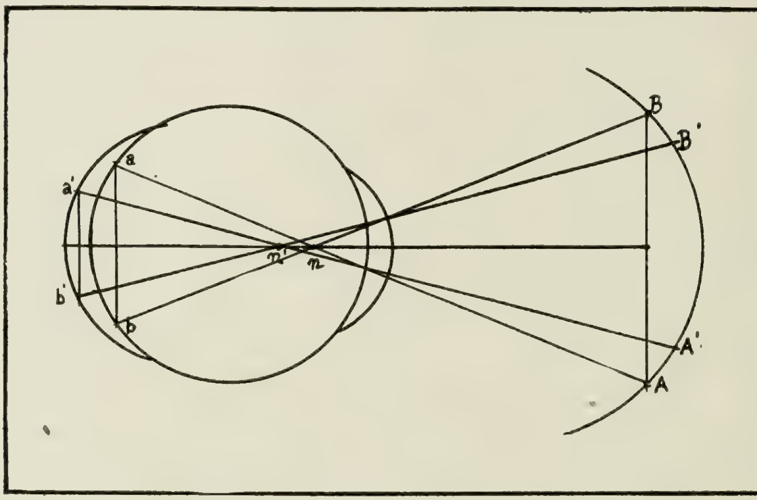


Fig. 5.
Showing the Influence of Hyperopia and of Myopia Upon the Field of Vision.

larger than that for red. These changes in the field we speak of as a "reversal of the field of vision." Such changes are often found in conjunction with marked organic disease sometimes indicated by a complete pupillary immobility.

(*D*) *Factors influencing the field of vision.* Let us now consider certain physiological factors which may influence the field of vision, and among the first of these will be the pupillary diameter, and the position of the pupillary plane. Visual acuity is greatest at the fovea centralis, and this, in the normal eye, is placed in such a way that the image of an object falls upon it. The point at which this image is projected outward is properly considered the center of the field of vision. The different meridians of the projected field emanating from this point are, as has been stated, not of equal length, and while this is in

part due to a difference of functional activity of the retina, it is not wholly due to this cause. The wider the pupil the wider the field since the light reaches more anterior parts of the retina. During accommodation the pupillary plane advances, and here, as in hyperopia, the nodal point is more anterior thus causing an increase in the field.

In hyperopia visual lines passing through the extreme pupillary margin and continuing through the nodal point on the shorter optic axis of the hyperope must reach farther forward on the retina.

The reverse is true in the case of the longer optic axis of myopia. In both cases the position of the pupillary plane either increases or decreases the field somewhat. In hyperopia the anterior chamber is shallower and the pupillary plane farther forward than in myopia.

Cranial configuration sometimes introduces a disturbing element, especially with a diminished facial angle so commonly found in the negro race.

That the influence of hyperopia and myopia may be better understood, it will be observed by referring to the previous figure (see Fig. 5), that in hyperopia the rays passing through the extreme periphery of the pupil, and continuing through the nodal point form a larger arc a. b. than the arc a′b′, which latter arc is formed by similarly described rays passing through the nodal point n′ as in myopia. In the former case, hyperopia, the retinal elements concerned in vision are affected farther forward than in myopia, and, therefore, the resulting hyperopic field A. B. is larger than is the myopic field A′ B′.

It is well to note the effect of myosis and mydriasis on the field. While the statement of Purkinjie that, under atropin, the fields of 100 were extended on the temporal side to 115 was confirmed by several investigators, Uschakoff (*Arch. f. Anat. u. Physiol.*, 1870) found an increase of but 2° after using atropin, while Donders, Emmert and Butts could find no difference in the field after the use of atropin. Baas (*Das Gesichtfeld*) concurs with the results obtained by Donders, Emmert and Butts, and believes that differences in the field taken with normal pupil and dilated pupil are not to be found, but he does think, however, that between the fields of extreme pupillary contraction and extreme pupillary dilation a difference exists. While it is frequently stated regarding this subject that wider the pupil the larger the field, the writer, in a number of cases recently tested, with and without dilation of the pupil, has found very slight difference.

The bony prominences about the base of the orbit may be factors in curtailing the visual field, for example, the bridge of the nose always to some extent limits the nasal field, and in some patients very markedly so. The tip of the nose contracts the field in the lower nasal

side, and the cheeks, mustache and lips may influence the inferior portions of the field.

The position that the eye occupies in the orbit itself is a factor. In some individuals the eyeball is situated very deeply in the orbit near the apex, while in others the normal condition is almost one of proptosis. In the latter case, the plane of the iris being anterior to the former, the anatomical obstructions just described do not exert so marked an influence.

The writer has very frequently had his attention called to the curtailment of the upper, the upper nasal, and the upper temporal field, through a redundancy of fat, or skin, of the upper lid. In individuals afflicted with adiposity, this curtailment is exceedingly noticeable, as the reader may notice by referring to the figure. (Fig. 6.)

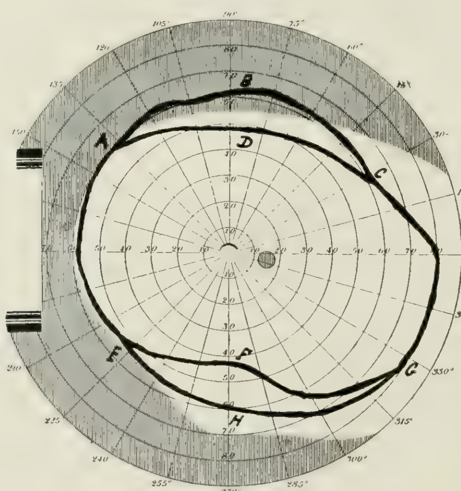


Fig. 6.

Showing the Curtailment of the Upper Field by the Eyelid, and of the Lower Field by Improper Position of the Eye at the Perimeter.

The upper limit of the field obtained in this man was marked by the line A D C. By holding the upper lid by the finger the field immediately extended to A B C, a difference in some places of 15° to 16°. This figure also illustrates how defective apparatus may abbreviate the lower field. The lower field limit E F G was obtained with a post holding the sight-point in position. This interfered with the lower field in such a degree that without it the field extended to E H G. This calls our attention to the importance of removing all such obstacles after proper position and fixation has been obtained. In these cases a properly constructed head-rest should only come in contact with the chin and sides of the head.

Race, age, sex, menstruation, administration of certain drugs, electricity, the accommodation and refraction of the eye, color-blindness, and glasses, as well as many other factors, have been investigated by

different writers to determine to what extent, if any, they modify the visual fields.

Schöler (See Baas 61-62) from investigations among savages and barbarians, as the Negroes, Nubians, Indians and other races, believes that the boundaries of the fields, as well as the color succession, about corresponds to those of Europeans.

He believes, however, that these races possess a keener color perception, which is in accord with the generally accepted idea that these races possess a greater visual acuity.

Women are said to possess more extended and better defined color-fields than men. Color-blindness exists in about 4 per cent of males, and is much less common in females, being only 0.02 per cent, according to Tscherning.

Plink and Baas did not find that age, where normal conditions exist, caused any noticeable, or practical, departure from the normal fields. Finkelstein (Baas, 62) states that during the period of menstruation there exists a narrowing for white and color, that is existent two or three days before its onset, and is at its height on the third and fourth days, and does not disappear until the 7th. This statement is not taken seriously, and the writer agrees with Baas that such changes, if such are found at this time, should be more properly considered in the class of "nerve asthenopia."

It is stated by Nagel, von Hippel and others that strychnia and electricity both increase the extent of the visual field. Many of these investigations were undertaken in pathological cases, and more properly concerned amaurotics and amblyopics.

Regarding the effect of glasses upon the visual field Landolt (*The Refraction and Accommodation of the Eye*) says regarding convex lenses: "When one looks through the edge of a convex glass, placed at a certain distance from the eye, and in such a way that its edge is just opposite the corresponding pupillary circumference, the point of fixation disappears and, with it, a more or less extended portion of its surroundings. This gap is greater in proportion as the glass is stronger and farther removed from the eye. This is easy to understand. Among the rays coming from the point of fixation, some pass outside the glass, but do not enter the pupil, since the glass entirely covers this; others are deviated by the prismatic edge represented by the border of the convex glass, so that they fall beyond the opposite margin of the pupil.

"If the center of the lens is placed in front of the pupil, the same results will, evidently, be produced for all objects situated on a line joining any point of the edge of the glass with the corresponding point

of the pupillary circumference. The field of vision of an eye furnished with a convex glass will, therefore, present a larger or smaller annular hiatus corresponding to the circumference of the lens.

"When one looks through the latter along its axis, this suppression of a part of the visual field is less troublesome in proportion as the glass is weaker as the gap remains more peripheral. But it may become a serious inconvenience for persons who, like those who have undergone cataract operations, use strong glasses, and sometimes look through their edges."

Regarding concave lenses he further states: "Just as in the case of biconvex glasses, the prismatic effect of biconcave glasses is manifested in all meridians. Only the lens may be regarded as composed of an infinite number of prismatic sections, whose apices all converge towards its center. It follows from this that, if one looks through the edge of the glass, so that it cuts the pupil in halves, objects are seen double, in part directly and, on the other hand, through the prism which displaces them toward the center of the lens. If, then, the eye, wearing a convex glass, has a gap in its field of vision, the concave glass, on the contrary, favours it with a zone in which it sees the objects twice."

Mauthner (*Die optischen Fehler des Auges,* 1876) states that concave glasses extend the limits of the visual fields in two ways: 1st. The wide incoming rays are refracted toward the concave lens base, and thus deflected further forward on the retina. 2nd. That the nodal point is placed farther backward. For directly opposite reasons he states that the convex lenses decrease the visual field. It is to be noted that the influence of the meniscus is less than the ordinary biconvex or biconcave lens.

Berlin (*Klin. Monatsbl. f. Augenh.,* 1869) wrote, relative to the influence of very strong lenses (cataract glasses) upon the periphery of the field of vision. He found a ring-like defect in the field periphery. The width of this defect depends upon the form and power of the glasses. He explains the phenomena of this ring scotoma in this way: often the rays between the eye and the glass reach the percipient retinal areas while at the same time the rays which fall upon the extreme lens periphery are so widely refracted that they are not preserved by the eye, and thus between these two areas is found the ring defect.

Convergence or divergence of the visual axes brings about a change in the relationship of the two nasal portions of the fields, which overlapping, give us the binocular field of vision.

In convergence this binocular area is diminished, in divergence it

is increased. We may conceive of the nasal field of the right eye—due to paralysis of the right external rectus—so far overlapping as to rest almost entirely within the nasal field of the left, or non-squinting, eye. With paralysis of the right external rectus the nasal field of the right eye overlaps the left nasal field less and passes more into the right temporal field. In either case the areas overlapping, not representing identical areas of the retina, form a *confusion field*.

In permanent squint with amblyopia of the squinting eye the visual acuity of the fovea is so slightly above the surrounding areas of the retina that fixation is imperfect and the eye oscillates in its search for a satisfactory point of fixation, and thus measurement of the field is difficult. In this case the image is suppressed and no confusion exists.

A factor that may influence the field of vision in one eye is the removal of, or loss of vision of, the other eye. That central visual acuity may greatly improve in an amblyopic and squinting eye following loss of the normal eye has been observed, and it is probable that the the peripheral zones of the retina increase in functional activity as well, as shown in a case reported by Johnson.

(*E*) *The relation of central visual acuity to the peripheral extent of the form field in the normal eye.* The question: "Does there exist, with a less than normal central visual acuity, an attendant, related, and proportionate drawing in of the field of periphery?" while involving the question: "Is the function of the peripheral rods and cones one that varies proportionately to the function of the macular rods and cones?" is yet a question that involves still more, namely: the factor of the influence of the refractive state of the eye.

As we may have different central visual acuity in emmetropes, or in ammetropes of the same degree, with normal fundi, likewise we may have in normal eyes, with the same central vision, different sized visual fields. It is to be remembered that the explanation of this is not always to be found in the retina alone; it may be cortical.

We cannot give to a particular degree of central vision a related and proportionate outward field extension. It is reasonable to expect with central visual acuity of 6/6 that the field limits will reach to the normal boundaries, but we may have, in an eye with less acute central vision, a wide peripheral field, and in another case, with hyper-acute central vision, we may find a field not extending to the normal boundaries.

This much may be said, the writer believes from his own observation that in myopia of a certain degree, for example—1.50 D. with central vision of 6/60—he has found very frequently some relationship be-

tween central vision and the extent of the visual field. To satisfy himself upon this point he has taken the fields of many myopes, arranged in groups from a lower to a higher degree of myopia, and has almost always found contraction that is slightly greater the higher the myopia, and its attendant diminished visual acuity for distance. Of course, it is to be remembered the degree of the myopia and diminished central vision for distance does not always imply diminished activity of vision in the macula, for at the near point of such an eye vision may be acute. And in myopia of high degree we may occasionally find torpor retinæ, owing to changes in the nourishment of the choroid, this condition causing—by diminished illumination—still

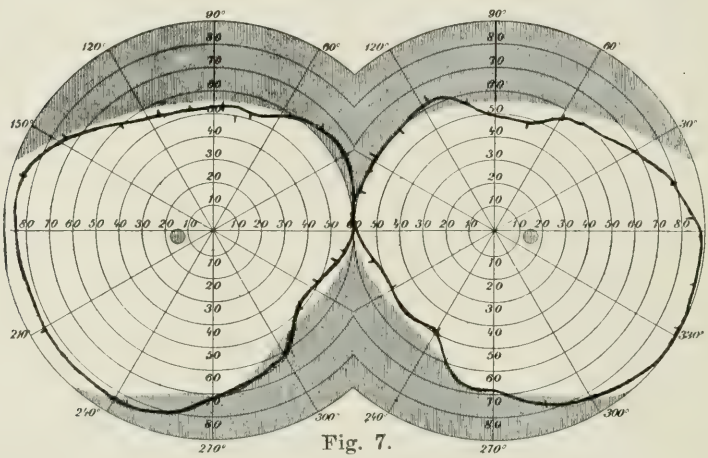


Fig. 7.

Showing the Right Slightly Amblyopic Eye With a Field as Large as the left Eye With Normal Visual Acuity.

greater concentric contraction than is usually found in myopia. When, on the other hand, diminished central vision is found in hyperopia, and especially where there is some amblyopia present, the proportionate correlation of the extent of the field to the central visual acuity is not present. It is well known to all ophthalmologists that sometimes the most perfect fundi, associated with low errors of refraction in healthy individuals, under the most careful fitting by glasses fail to yield normal central (6/6) vision. In such cases where central visual acuity is represented by 6/9, 6/15 or even 6/60 the peripheral fields may extend to the widest limits demanded by our accepted normal fields. The accompanying figure 7 shows in the same patient that the amblyopic right eye, with vision of 4/60, has as good, in fact a little better, field boundaries as has the right eye with vision of 6/6. In the right eye with a correction of $+1.25 = .37$ axis 90, vision was

6/6; in the left eye with a + 4.00 sph. vision was 6/22. There was no change in the fundus of either eye.

In considering the myope with a diminished peripheral field, and the hyperope with a normal field limit two factors at least are concerned in the explanation; the one organic, concerning the rod and cone elements; the other refractive, concerning the change of plane of the iris, nodel point and retina. Where, with diminished visual acuity and diminished field periphery, we find the correcting error of refraction gives normal vision of 6/6 to the eye, we may assume that the gradual variation of the rod and cone sensibility from the macula through the central, the intermediate, into the peripheral retinal zones, is physiologically correct in its proportion, i. e., that the numerical arrangements of these elements from macula to ora serrata is a normal one, and that the decrease in sensibility to luminous impression going from macula to ora serrata is likewise a normal decrease.

In this case we may properly ascribe the slightly contracted field to the myopic refraction; thus given a certain degree of myopia, as expressed by certain attendant visual acuity, we may, in a series of cases, find that for every series, from greater to lower, degrees of field limits that bear close relationship to the central visual acuity, and the degree of the myopia.

In the hyperope, and especially with associated amblyopia, it is different. The activity of the rods and cones near the macula to luminous impression is diminished, and is, perhaps, not much above the activity of these elements in the outlying retinal portions. In these cases where vision is 6/60 or 6/30, and perhaps not improvable to over 6/12 or 6/9 by the best refraction, we may have full peripheral fields, since the position of the planes of the iris, nodal point and retina are more favorable to a full field than in a myope with vision of 6/60, and whose peripheral rod and cone area may be quite as good or better than the latter. Here the central visual acuity of the slightly amblyopic eye is more representative of the acuity of the entire retinal portions than is the visual acuity in the myope.

Thus the writer believes that, in so far as there may exist a definite relationship between different degrees of central visual acuity with different degrees of extent of field periphery, it is to be observed only in myopes free from fundus changes. In myopes whose visual acuity is in addition to the myopia, further decreased by observable, or non-observable, changes in the retina or other percipient parts of the sight organ, one can find no relationship of fixed character between central vision and peripheral vision.

Likewise in those cases of diminished visual acuity in hyperopia

attended with amblyopia, we can find no such fixed relationship between the expression of the light-sense in the central field and the limits of the peripheral field. Of course, these remarks do not bear upon concentric restriction with diminished central acuity of vision occurring in organic diseases. This relation of central to peripheral vision will be discussed in its different appropriate places, especially under atrophy of the optic nerve.

(F) The binocular field. Thus far we have discussed the monocular fields of vision alone, but, in their projection outward into space, a portion of each of these fields overlaps the area of the other field, to the nasal side, giving us the so-called binocular field of vision. We observe that the binocular field is that area of the combined fields of vision in which the eyes participate in the visual act in common. This area known as the binocular field is not to be confused with *the combined fields* of vision, which consist of the binocular field plus the added area of each of the monocular fields, which does not participate in the act of binocular vision. This area of binocular vision subtends an angle of about 120°. By referring to the figure 8 we have "A," showing the right field of vision, "B" the left field of vision, and below these two fields, in "C" the one is superimposed upon the other. In normal balance of the ocular muscles the vertical meridian A B″ with its contained fixation points F F′ F″ is common to both the left, right, and the combined fields of vision. In (C) it is to be observed that the nasal field of the right eye A B C is represented by A″ B″ E and takes its place in a portion of the temporal field A′ B′ C′ of the left eye. Likewise the nasal portion of the field of the left eye A′ D′ B′ is represented by A″ B″ E′ and takes position in the portion of the portion of the temporal field A D B of the right eye. These two overlapping areas A B C and A′ B′ D′ form a field A″ E′ B″ E in which vision is common—binocular—to both eyes, and known as the binocular field and as the field of stereoscopic vision. The shaded portions constitute the area of purely monocular vision. In the binocular field no physiological blind area, (Mariotte's spot), is demonstrable since the blind area in one eye overlaps in the other eye a functionally active area.

The field of vision for each eye, in man, subtends an angle of about 135° and within the combined fields is an area in which the visual fields overlap, the area subtending an angle of about 120°, as stated. In animals lower than man this field of vision common to both eyes grows less according to the position of the globes and the consequent change of position of the axis bisecting the central points of the retina. In man these axes are prolonged backward, meeting and form-

ing an angle of less than 45°. In the dog they form an angle of about 90°, in the horse about 135°, while in the rabbit the axes lie almost in the same line. It is evident that the more nearly parallel the axes

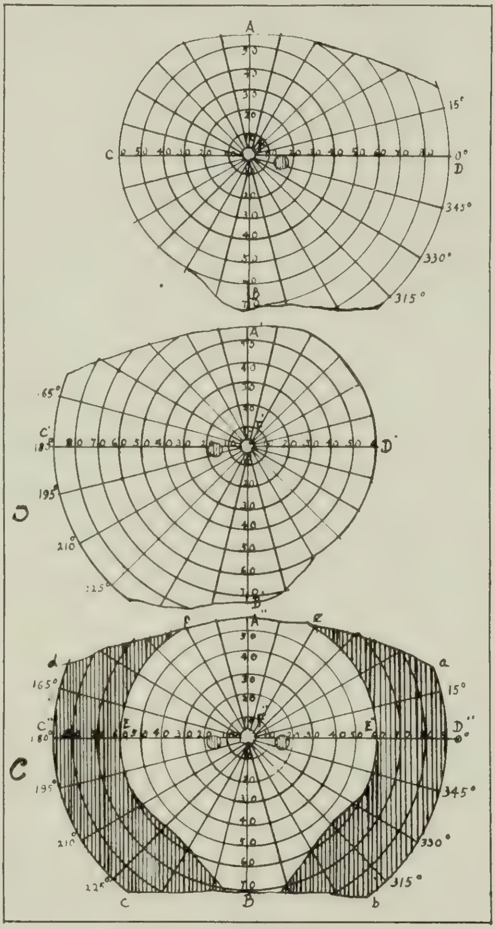


Fig. 8.
Showing the Right and Left Fields, and their Projection Forming the Binocular Field, Together with the Right and Left Monocular Fields.

are with one another the greater the overlapping of the fields, and the greater the area of binocular vision will be.

There is a direct relationship between the uncrossed fibres in the chiasm and the size of the binocular field; the larger the bundle the larger is this field. In the lower animals where total crossing of the optic nerve fibres is present the binocular field disappears entirely,

the eyes being separated laterally to such a degree that each field is independent. In the higher animals a small binocular field exists.

The binocular field is the field of stereoscopic vision. This function is possessed, although in a lesser degree, by the monocular field. It is well known that we refer our visual sensations to space of three dimensions. Beside a perception of breadth and height, we also have in vision a perception of depth, which is the least perfectly developed of the three.

The knowledge we obtain of depth, i. e., the varying distances of objects from the beholder, is gained in two ways; by experience, and by sensation.

When objects, as of persons, which we know to be of about the same size, give images of different sizes, we attribute, by experience, a greater distance to the smaller object. In regard to sensation, Wundt (*Theorie der Sinneswahrnehmungen*), after experimentation, concludes, that the feeling of accommodation gives us no information in regard to the absolute distance of an object, but only in regard to its relative distance, and that the less the absolute distance is, the more certain the estimation of the relative distance. These remarks refer to depth in the monocular field, and Tscherning (*Physiolog. Optics*) states that monocular judgment of direction is better than with two eyes since the latter—binocular vision—has certain illusions from which single vision is exempt.

In binocular vision a slight non-identity of the two retinal images, and the degree of convergence necessary to fix an object, are the important factors in affording us knowledge of the absolute and relative depths, that is to say, stereoscopic vision.

By "Antagonism of the visual fields" we understand that the images placed in the two fields are so different that they cannot be fused. For example, if we place before one eye horizontal, and before the other vertical lines, we observe this phenomena; that sometimes the one, and sometimes the other will predominate, while the one predominates, the other image is suppressed. The reader is referred to Tscherning, as well as to Helmholtz's classical work, for experiments relating to this subject.

Binocular vision is acquired during the very early life of the infant. At first the eyes wander aimlessly, then soon learn to fix, thus marking the accomplishment of the binocular act.

METHODS EMPLOYED FOR THE EXAMINATION OF THE VISUAL FIELD.

The methods practised for determining the boundaries, and the condition of the field that lies within these boundaries, may be placed under the following headings:

(1) *The direct method;* or the taking of the visual field with the patient standing directly before the examiner, using no instrument other than the white, or colored, test objects, held by the examiner in his hand, or on a test stick.

(2) *The blackboard method;* or that of obtaining the field by marking its limitations on a blackboard placed before the patient.

(3) *Arc perimetry;* or the testing of the peripheral (and sometimes central) visual field on various types of instruments known as perimeters.

(4) *Scotometry;* or the measurement of the variously-shaped defective areas lying within the peripheral portions of the field.

(5) *Exceptional methods;* or those employed for obtaining the visual fields of patients partially blind, mentally defective, aphasic, or injured.

(1) The direct method. This, the simplest and most quickly applied method, is carried out in the following way: The patient is placed standing upright, his back to the light and facing the examiner, at a distance of about one arm's length. The eye not under examination is covered with a small pad, which is lightly applied in order not to induce pressure upon the globe. He is then directed to fix, with the eye under examination, at the pupil of the examiner. With the reversal of position he would thus, with his right eye under examination, be looking at the left eye of the surgeon. If, owing to a very high error of refraction, or to disease, central vision be so diminished that the pupil of the examiner cannot be clearly seen, the patient is told to watch the eye, or the region thereabout. The light entering the room should not be too intense, for noticeable contraction of the pupil may have its influence upon the test. The patient should not be too close to the examiner, since this brings the accommodation into play, altering the pupillary plane, and thus, again, further affecting the results obtained. The examiner brings a small white test object, such as a piece of cotton or white paper, held in his fingers, from the periphery of a plane midway between the eye under examination and his own eye.

The hand of the examiner must be bent so that the test object is seen before any portion of the arm, or hand itself, presents. The writer uses a small, almost invisible, wire test stick with the test object held thereon. Some examiners use for this, and as well as for certain other field tests, a black glove over the hand.

Both for this test and in arc perimetry it is well to have a black curtain or background behind the examiner. The cuffs of the examiner should be invisible, for it is confusing and often difficult for the

patient to tell whether the first impulse of white arises from the white cuff or the object. Again it is an error for the examiner to direct the patient to close the eye not under examination, rather than to cover it, for this affects the upper lid of the eye under examination, and gives a lessened upper field.

This direct test possesses value only as a preliminary office routine, in case the ophthalmologist suspicions changes in the visual field, although gross defects, especially marked concentric contractions, hemianopsia, and even the larger scotomas, may be discovered, and some valuable information pertaining to them brought to light, but, after such discoveries are made, this test must be followed by one or more of the more accurate methods, whose descriptions follow.

Again, by sometimes moving the fingers, or the test objects, and then allowing them to remain still, and in requiring the patient to announce when they are in motion, or when they are still, this test is given the force of an objective test, as has been pointed out by Jackson, since the results do not rest upon the patient's unsupported statement that he sees, or does not see, the object.

This test also has some small value in training the patient to a more intelligent attitude toward the perimeter before such perimetric tests are taken, and thus, beforehand, the examiner is able to estimate the probability of accuracy, or inaccuracy, in these tests to follow.

Jackson (*Oph. Rec.*, May 1896) states, that he often uses this direct method in testing the color fields, and here makes a rather unusual, and possibly valuable, suggestion. Several different colors are held in the hand not used for holding the test object, and he picks out one of these colors with the test hand, and, without looking at it, carries it to the extreme border of the field and from this point gradually moves it toward the center until the correct color is called, giving, therefore, a test of some value as an objective one. He (Jackson) states that it is important in making this latter test that the examiner himself be unaware of the color under test, thus not giving him the advantage of knowing what the color is that is advancing from the periphery of the field. He states that in testing for central color scotoma by this method, that it is important the patient be not given a chance to recognize the color tried by exposing it at some part of the field outside of the scotoma. This he provides against in the following way: he takes a large sheet of paper with a hole of the proper size near the center, having the patient keep his eye steadily fixed on this hole. Several colors are concealed beneath the paper and he exposes one after the other, each time requiring the patient to name the color so exposed.

It is assumed in this test that the eye of the examiner is normal in visual acuity, and that it possesses a normal field, and thus if the field of the patient under examination be also normal, he will perceive the approaching test object synchronously with the surgeon. Should the vision of the patient, especially his central vision, be so defective that the test object, or even the hand, be not discernible, the use of illuminated test objects, in a manner later described, is indicated. This in the case of cataract—generally spoken of as determining the "light projection"—is but another means of defining the sensibility of the retina to stimulation.

This, designated the direct method of examination of the field, has little or no value for accurately determining the limitations of the color field, and, as stated, is only a rough method for obtaining the outlines of changes occurring in the form field. However, when one is accustomed to this method and is very careful to keep the test object in a plane midway between the patient and himself, quite satisfactory results may be obtained. It has the advantage, furthermore, that the patient's eye may be watched by the examiner and thus perfect fixation of this eye constantly obtained during the test.

(2) The blackboard method. In this method, introduced by von Graefe and afterwards improved by de Wecker, the patient stands upright at a certain distance from the blackboard and fixes its center with the eye under test. The test object, held on a small staff, or in the hand—which may be covered with a black glove—is moved over the various concentric circles and meridians which have been drawn on the board. The points of its appearance into the field, and disappearance in the field, (if we are dealing with scotoma), are noted by marks on the meridians and circles. Eight, or preferably sixteen, such meridians should be taken in this way, and these points connected up by lines delineate the field.

In cases where a field of not exceeding 45° is desired this board method outlined by von Graefe, and improved by de Wecker, is both practical and useful. Beyond 45°, however, the test is entirely unreliable. Instead of, as in arc perimetry, having the test object at the distances of equal radii, this method, as Wilbrand pointed out, suffers from the fact that the radii on one side of the point of fixation are all different. In other words the test object is seen at different distances at different parts of the retina.

Furthermore, as shown by Helmholtz, the refractive power of the cornea and other parts of the dioptric apparatus is so great that rays of light are still perceived which fall upon the cornea perpendicularly to the optic axis. Therefore, rays parallel to the blackboard, whose

limits are infinity, are perceived by peripheral portions of the retina, and even more, since it is to be noted that rays which make more than an angle of 90° with the optic axis, still fall upon the cornea and are reflected to percipient portions of the retina, (note Baas' 99° temporal field), it is thus manifestly impossible to define the limits of the visual field upon a flat surface. The explanation of this is shown in the accompanying cut (see Fig. 9), which at the same time shows how, in making the blackboard test, the test object is seen at different distances at different parts of the retina.

By reference to the figure it will be observed that the line A. B. represents the flat surface of the blackboard, and the arc A′ F B′ that

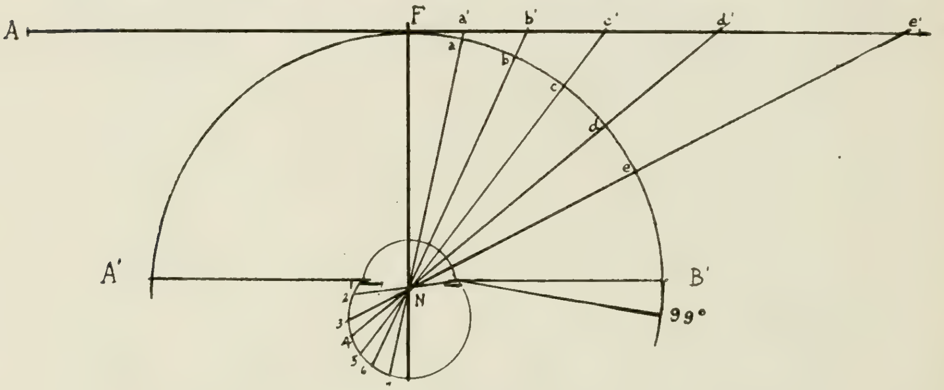


Fig. 9.
Showing the Projection of the Field on an Arc and on a Flat Surface.

of a perimeter. Upon the latter arc all projected rays from the retina are of equal radii, and in this figure these radii are so drawn on the arc that the distances between a-b, b-c, c-d, d-e, are equal. When these rays are projected out beyond the arc onto the flat surface A. B. we notice that the equal distances shown on the arc are of very slightly different values on the flat surface up to about 45°.

However, when those radii which are exterior to 45° are projected we notice that equal distances on the arc become unequal distances on the flat surface, as notice the equal distances a b—d e on the arc become the greatly unequal distances a′ b′—d′ e′. It is thus to be seen that the different parts of the retina when measured on a flat surface are seen at varying distances.

The greater the distance from the eye the smaller the retinal image must be, therefore, if the same test object be used, it is a manifestly incorrect field we obtain, for with test objects of unvarying size we are obtaining different visual angles at the points F. B.

In the next figure is shown a chart which Jeffries transcribed upon the board for the purpose of noting the extent of the visual field. This board is marked out in squares, and the fields of the squares on a board so marked when the eye is placed at exactly 25 cm. from the fixation point is as follows:

2.2 cm. = 5° in the perimeter semicircle.
4.4 cm. = 10° in the perimeter semicircle.
6.7 cm. = 15° in the perimeter semicircle.
9.1 cm. = 20° in the perimeter semicircle.
11.7 cm. = 25° in the perimeter semicircle.
14.4 cm. = 30° in the perimeter semicircle.
17.5 cm. = 35° in the perimeter semicircle.
21 cm. = 40° in the perimeter semicircle.
25 cm. = 45° in the perimeter semicircle.
30 cm. = 50° in the perimeter semicircle.
36.7 cm. = 55° in the perimeter semicircle.
43.3 cm. = 60° in the perimeter semicircle.

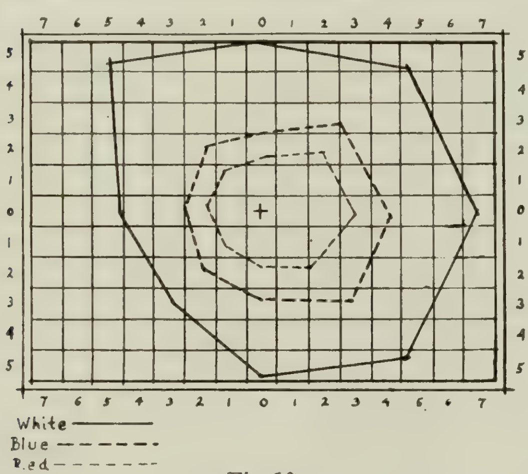


Fig. 10.
Jeffries' Chart.

The writer uses the blackboard simply having thereon a cross at the level of the patient's eye, and marking on the board the field limits. These are connected up and the field extension in degrees obtained by placing a small frame with the squares marked off by a series of crossing strings, over the board. He finds this elimination of a marked blackboard less confusing to the patient. The frame may be so arranged that the size of the square can be quickly changed to suit the distance of the eye from the point of fixation.

(3) *Arc perimetry.* Recognizing the limitations and inaccuracies of all methods in which a flat surface was used to obtain the periphery of the field of vision, Förster devised an instrument (see Fig. 11) known as the perimeter. It is virtually an arc, which, rotating about a pivotal point, forms a hemisphere. This point is used as the fixation

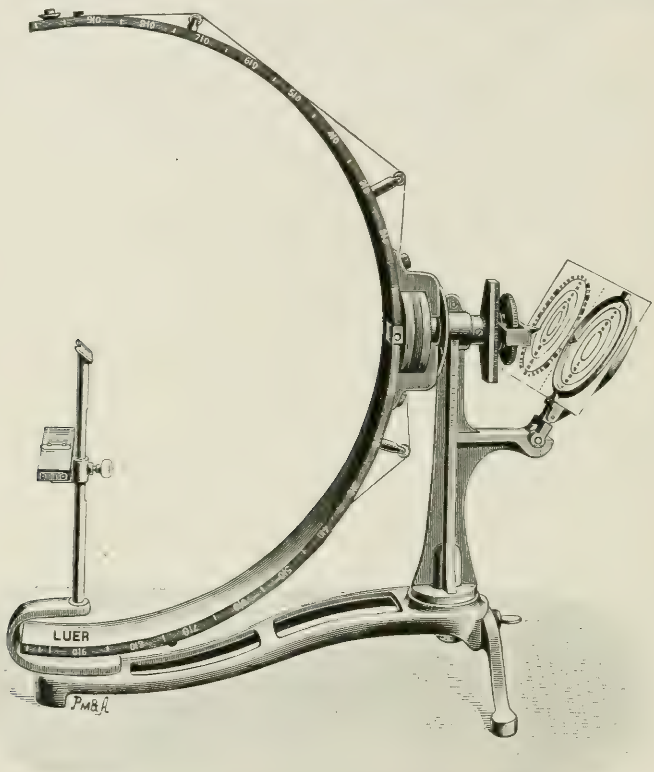


Fig. 11.
Förster's Perimeter.

point, and the metal band forming the arc is marked in degrees increasing from the fixation point outward up to 90°, or more. The patient's eye is placed at the center of this arc at about 30 centimeters distant from the point of fixation. Accurately speaking the radii of the arc are each exactly 31 cm. and as the nodal point of the eye should be exactly in the center of the sphere of which the periphery band forms a part, the support holding the chin rest must be shorter than the support holding the arc. The arc is sufficiently large to measure fields of more than the average extent.

Förster's original perimeter was so arranged that the patient fixed

a small ivory ball, which was placed eccentrically 15° to the nasal side of the center of the peripheral arc, making the physiological blind spot the center of the field. Perimeters have been constructed with a perforation at the point of fixation. The patient is directed to look through the small hole at a distant object. This is to avoid ciliary con-

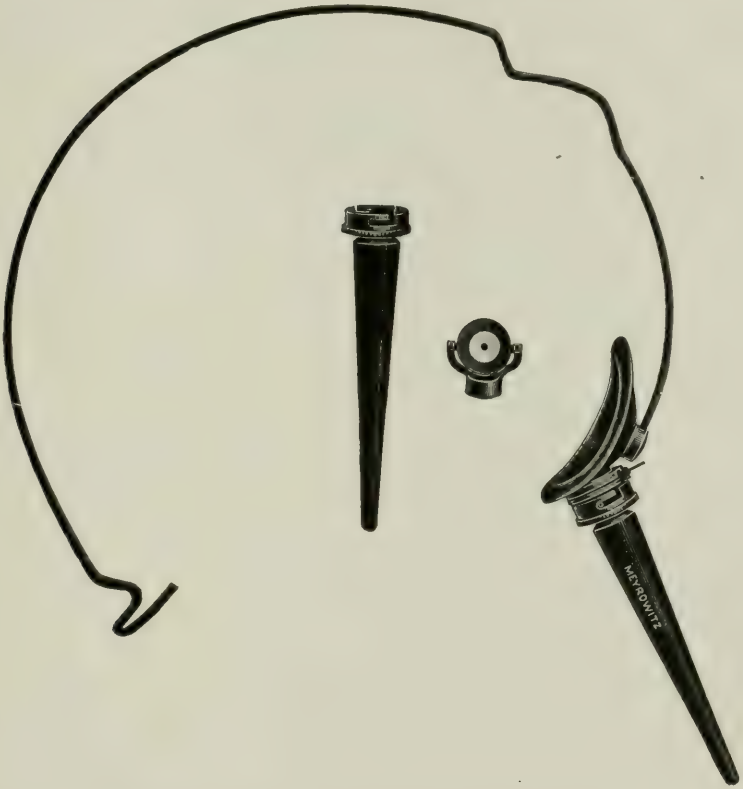


Fig. 12.
Combination Blinder and Macular Selector (Walker.)

traction, as well as pupillary contraction with consequent change of the iris plane, which in itself affects the field of vision.

Mauthner in order to disclose the entire field of vision, had the patient fix at 30° from the center of the peripheral arc to the nasal side. Measuring this way a much larger, what he calls a maximum, field was given. Each meridian was measured with the eye fixing in this point on the arc.

The eye not under examination should be covered by a light pad, or, what is much better, by the special blinder, which for this pur-

pose may be used apart from its usual connection with the instrument known as "the macular selector." The usual method of blinding one eye with a bandage or pad, as at first suggested, has certain difficulties among which is that they are time-consuming, and, what is more important, may obstruct the vision over the bridge of the nose, or, on the other hand, permit of some visual leakage from the covered eye, over, or down, the side of the nose. To obviate this the blinder spoken of has been devised. It consists (see Fig. 12) of a hemispheroidal shield, which fits the orbital rim of the eye, and is held in place by a light spring on the head. The head spring is attached to the shield by means of a swivel joint, so that the spring immediately takes any position comfortable to the patient, it will allow free motion of the eye, while at the same time it excludes all light. This spring is readily bent so that it may fit any size head, such as one finds in microcephalus, hydrocephalus, or in cases where there is much hair on the head, as in elaborate coiffure. The apparatus is readily sterilized by alcohol or ether, or even by boiling.

The head is so adjusted that the eye under examination lies at a point which is just high enough above the ledge to permit of fixing at the fixation point of the perimeter, which is generally indicated by a white button. This position brings the nodal point of the eye at the center of the sphere described by the perimeter's arc.

A comfortable seat with a properly constructed table, which should be adjustable for height, and which also permits the hands, or forearms, of the patient to rest thereon, is necessary. The face must be vertical and not tilted to one side.

Position of the eye, in relation to the perimetric arc, and also correct fixation, are of the greatest importance if accuracy is to be obtained. If the center of the eye does not correspond to the center of the perimeter arc, almost any kind of a field may be obtained for, by extending the radius backward, there is an increase in the size of the arc obtained and thus a correspondingly enlarged field. To be assured that the eye is in the center of the arc Howe attached a gun-sight to a carrier on the arc of the perimeter, the two points of the sight being in the line of a radius of the arc. He also attaches an electric light to the concave surface of the carrier and covers the light with a tube pointing toward the center of the arc. He claims more constant results by these modifications.

The perimeter is placed with its concavity toward the incoming daylight and it is quite proper, even advisable, to place it between two windows. There should be no incoming daylight back of the examiner, and one may drop a black curtain immediately back of himself to avoid

distraction of the patient, and affecting of the light sensibility of the retina. These precautions also reduce the pupillary changes to a minimum, which, as has already been stated, affects the field. In carrying the test object while in the peripheral regions of the field, it is neces-

Fig. 13.
De Zeng Standard Perimeter.

sary to move it to and fro, since in sustained central fixation an object at rest disappears too rapidly, due to simultaneous light induction, as pointed out by Hering.

However, as a common practice, wide oscillation of the test object is not permissible, since a larger area of perceptive elements being stimulated, we have, in effect, a result from a larger test object than the one in actual use.

Jackson (*Oph. Record,* May, 1896) states "In measuring concentric or approximately concentric contraction of the field, the arm of the perimeter should be fixed at a certain meridian and the test object moved along it. In studying a hemianopsia, or a sector defect of the

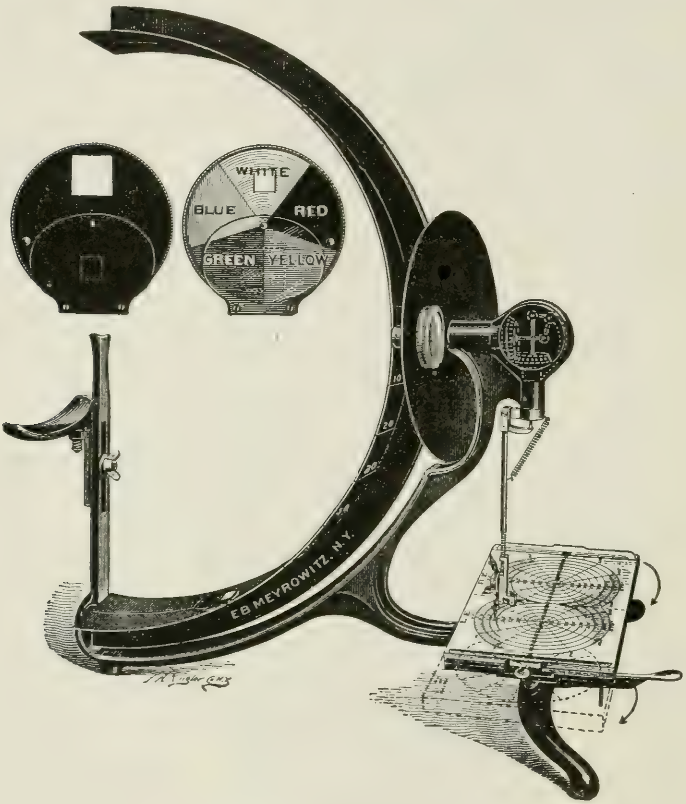


Fig. 14.
Skeel's Self-Registering Perimeter.

field, the test object should be fixed at a certain point on the arm of the perimeter; and the arm revolved so that the test object shall describe a circle about the fixation point. The determination is most accurate when the movement of the test object is perpendicular to the line bounding the field of vision.

The facility with which the test object may be moved in every direction, and so may fix all the boundaries of the scotoma with equal accuracy is the advantage of the blackboard in mapping a scotoma. For ring scotoma one should use the perimeter as for concentric contraction."

The later model perimeters are so constructed as to carry simply a revolving graduated quadrant, and have a very perfect recording mechanism. Such instruments (Fig. 14) are called self-registering perimeters. In these instruments a steel point follows each motion of the test object, which is adjustable to the required size and color, and which is caused to travel along the arc of the perimeter by cords connected with the mechanism controlled by a large milled head at the back. The chart is held in the adjustable support of ample size as shown in the illustration, and is pressed against the projecting steel point for record.

Test objects and their illumination are controlling factors in determining the extent of the field. This is especially true of the color fields. The taking of the visual field is in part a study of the light sense, in part a study of the acuity of vision, and in part a study of a color perception in the retina, therefore illumination has much to do with designating the degree of each of these senses. As in using an ordinary test card for visual acuity, vision of 6/9 with moderate illumination may become 6/6 with more intense illumination; so with the retina, in its power to distinguish colors toward the periphery of the field, do we find light intensity a most important factor. Gowers and others have shown that with larger areas for test objects these fields differ very little, if at all, from the fields for white.

Wolfberg, however, while insisting that fields obtained under ordinary daylight should be "controlled" by tests made under reduced illumination, believes that fields obtained in the same person in good daylight will correspond to fields obtained under reduced illumination, if the reduction be not so great as to render the fixation point invisible. In order to obtain results of comparative value the white field and the color fields must be taken under identical conditions and under equal illumination. Illumination of the test object by electricity in the so-called "electric perimeters" is advocated, and such instruments are used by many ophthalmologists. The intensity of the illumination is controlled by a rheostat, and the tests made in a darkened room.

The advantages claimed by these advocates are many, such as constancy of illumination of the test object, slighter variations of the pupillary diameter, etc. Since the condition of the physico-chemical retinal elements, the dilated pupils, and other factors are so different in a darkened room than in ordinary daylight, and, as already observed, the possibility of increasing the color fields by artificial illumination, the writer still prefers to take the field in natural light. In the dark-room the test resolves itself to a considerable extent into a test of the light-sense alone.

The model of a perimeter is important, but the methods employed and the intelligence of the man back of the perimeter are more important. The time-saving devices and mechanisms to obtain accuracy are many. A very excellent instrument, beside those mentioned, is the one devised by Hare, of New York. (See Fig. 15.) In this instrument

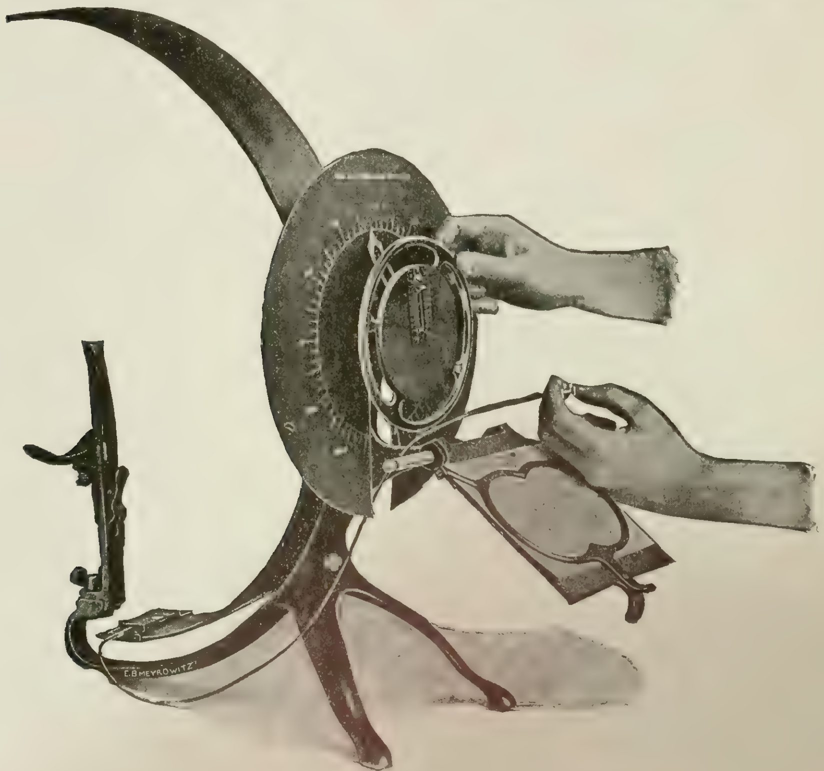


Fig. 15.
Automatic Perimeter (Hare.)

motions of the object carrier and the recording apparatus are automatic and insure accuracy.

The instrument consists of a semi-circular arc revolvably mounted on a stand, of which the chin-rest and guide for the eye are integral parts. Revolving within the main shaft, on which the arc is supported, is another shaft extending through to the arc by means of which the object carrier is operated by rotation of the hand wheel.

Attached to this shaft is a circular plate (not shown in cut) having upon its face a spiral track; operating in this track is the recording pin, the motion of which is limited by means of a slot in a covering

disk to a motion to and from the center along one radius. The operation of the object carrier is, therefore, as follows: When the hand wheel is rotated, the object carrier is made to move along the arc to and from the center, imparting to the recording pin, through the rotation of the disk with spiral track attached to the shaft, a motion similar but reduced in range to lie within the limit of the perimeter chart. When the arc is moved into a different meridian the entire recording mechanism moves with it. When a record is desired it is merely necessary to press the chart, which is carried on a flat plate hinged to the stand, against the steel recording pin; a puncture on the chart, corresponding to the position of the color carrier, is thereby made. The large disk or shield shown in the cut serves both as an axis indicator and to screen movements of the operator's hands. The disk is readily removable, making the instrument available for the measurement of the degree of strabismus by the angular method. The position of the movable object in degrees from the center is shown in the scale alongside the slot in which the marker moves.

Another most important feature is that the colors exposed in the carrier are changed by means of a flexible shaft, extending backward and manipulated by the operator back of the shield or disc. It is possible, therefore, for the examiner to make a change in the color of the object exposed without giving any clue to the patient. By means of a revolving diaphragm the colors may be shown in four different sizes—circles of 1, 3, 5 and 10 mm. diameter.

The old method of changing buttons or rotating the color carrier by introducing the hand into the field was an interruption to the examination, and distracted the patient's attention, so that each time a new start had to be made. With the present method of changing the colors the entire examination can be gone through much more quickly, because there need be no interruption, nor is it necessary for the operator to introduce his hand into the field.

The chin-rest is adjustable for right or left and for height. The operating shaft is pierced through its center, permitting the operator to keep the patient's eye under constant observation.

The charts are "double," i. e., both right and left eye records printed on one chart; the normal field being outlined. The charts are held firmly in place by a frame-clamp with marks to indicate when they are in proper position to receive the automatic record.

It is not necessary, however, for one to have these expensive mechanisms to do good work, but as the taking of the field is one that demands often much time, a good perimeter with its time-saving and

accurate mechanism is almost indispensable to the busy ophthalmologist.

We must also consider the character of the test objects with which our tests are to be made. These objects should have a reflexless surface rather than a glazed, glass or celluloid surface, which at certain angles show a strong reflex and thus affords neither a color or a form test. An excellent test object devised by Walker is shown herewith. (See Fig. 16.)

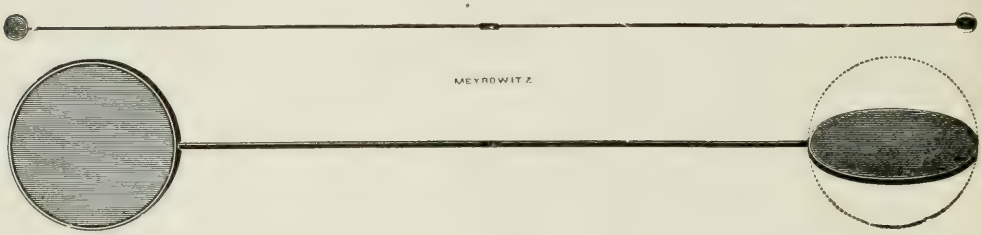


Fig. 16.
Graduated Discs for Test Objects (Walker.)

These test objects consist of a handle, having mounted at each end a circular disk on each side of which a different color is shown. These disks are mounted at right angles to each other, so that only one color is visible at a given time. The retaining rim is made with a knife edge, and the objects are therefore essentially rimless. The objects are made in seven sizes, and the area of each object, not the diameter, is stamped on the handle. The smallest disk is 1/64 sq. cm.; the largest one 16 sq. cm.

The white disks should be narrow and almost invisible for if large they may be seen by the patient before the test color itself. As the area of a round 1 cm. test object is three-fourths of that of the square cm. test objects, it is to be noted that the square offers greater visual stimulus even if these areas are the same. As to color the best source for a fixed standard is undoubtedly the solar spectrum.

Rönne (*Klin. Monatsbl. f. Augen.*, 1911, p. 154), in Bjerrum's clinic, shows the value of different sized small discs in taking the fields in cases of glaucoma and optic atrophy, and believes that a field examination with only one size of disc is as unsatisfactory as a test of visual acuity would be with only one size of letter. Walker, in Cushing's clinic, uses a circular area of one square centimeter as the unit size and varies the size so that the area of any disc is one-fourth the area of the next larger disc, or four times the area of the next smallest.

As will be subsequently shown the latter are useful for testing for central color scotoma. Walker has devised an ingenious "color inter-

changer and interlacing tester'' (see Fig. 17), which he describes thus: Roughly the instrument suggests the general arrangement of a tonsillotome. The movable rod carries at the end an essentially rimless white disk, and farther back the colors, which abut each other to get quickest possible interchanging, are protected by slight lateral rims. On the handle end of the rod are notches which lightly engage a tension spring each time a color appears at the central display opening. The spring may be regulated in tension by a double set screw, so the click on engaging a notch is not heard at all but barely felt by the operator. At the two end-stops for colors no click, of course, is necessary. To make the white spot appear requires more force than to display the colors, since in so doing more tension is put on the spring by means of an elevating cam. The ring on the handle for the thumb is on a swivel, so that any part of the perimeter is readily reached if the fingers are entered on the same side as the colors appear.

Fig. 17.
Color Interchanger and Interlacing Tester (Walker.)

In getting the form field the white spot is made to precede the rest of the instrument, so that the first motion noted is surely not due to the handle. The colors ride very close to the beveled opening, so that practically no shadow is to cut down the area of the disk, and a slight allowance is made in the size of the opening to offset the slight shadow present. The disks, protected as they are, do not fade or get soiled for months, and when necessary they can be replaced by loosening a small thumb screw on the handle, which allows all parts to be separated when the protective back end is slipped off.

Such an instrument serves a double purpose. First as to speed and ease. The entire eight readings for a form and color field may be rapidly taken, checked and rechecked at each setting of the perimeter, and throughout the examination it is not necessary to change one's position at the right or left of the perimeter, since the measurements may be made with one hand and recorded with the other, without interruptions ordinarily experienced in changing disks.

With some patients of minor intelligence it may be necessary to run rapidly around the form field separately where there is reason to suspect any confusion. The rapidity with which a complete field may be accurately taken is a great advantage when there is considerable

suffering and nervousness, as is frequently the case with patients who most need a field examination and are least able, on account of their physical condition, to make accurate observations for any length of time.

Secondly, it serves as a special test for the presence or absence of phenomena of color interlacing or inversion. Certain critical tests may be made in questionable cases. One may carry the red color to the periphery for red, and, without intimation to the patient or with a question as to whether the color disappears or not, noiselessly and quickly change to blue, when, if inversion is present, there will be no color called, while ordinarily it is at once noted. Green may be introduced to further reduce the chance of guess. Again the blue periphery may be found in the same way, and the red interchanged as before, with the same question, when, if interlacing is not present, the color will have to be brought nearer the center before it can be named. Also the colors may be continuously interchanged as the instrumnt is carried slowly along the arc, noting which color is first called. Color interlacing is not at all difficult to get even in normal cases when one color field at a time is taken, as is necessary with many automatic perimeters, or even with slow changing of colors, especially when the patient is allowed a large percentage of guess, of which they are usually glad to take advantage.

For perimetery Holt uses square ebonite blocks (fixed on hat pins), the four sides of which contain holes 5 mm., 10 mm. and 15 mm. square, fitted with white, rose, blue and green wax.

As a time-saving device in the detection of slight color scotomas, Snydacker (*Arch. of Ophthal.*, March, 1911) has made use of small colored squares which he has placed on a test card.

He uses red squares 2½ mm. and 5 mm. in size, and green squares 3 mm. and 6 mm. in size, the test being at six meters. When the patient cannot distinguish the small squares one may be suspicious of a color defect and should make a perimetric examination. In recording fields on the chart, black may be used for the white field and colors corresponding for the color fields. At least eight, and for accurate mapping of the field, sixteen meridians should be tested. The matter of notation of the visual fields is one worthy of consideration. It will be observed that there are several different kinds of charts whose meridians are marked differently.

In taking the color field, the test object should correspond in size to the test object for white, and each should be of a perfectly saturated color, that is, free from mixture with white.

On the continent of Europe the so-called Heidelberg flower paper

is used. Von Reuss points out that in all of our color paper used in testing, there is in the red, and also in the green, much of yellow, and when such test objects are first perceived it is as a partially yellow one. He asks: "When, then, in using red, is the point reached that this yellow is sufficiently red so as to be designated red, and when, in using the green, is it sufficiently green to be called green?" In this matter he desires always that the object, if red, be sufficiently so to no longer retain any yellow, green or blue color. The difficulty of stating the exact point can be learned if the observer himself tries to determine while seated at the perimeter. In fact, these considerations cause us to remember the statement by Cushing that "Good perimetry depends not so much upon the perimeter, as on the man behind the perimeter."

It seems appropriate at this point to define certain terms which are employed in discussing the color-field of vision, and its measurement. *Hue* depends on the wave lengths of the rays; *intensity* on the amount of light falling on a body in a given time; and *saturation* on the amount of white light falling on the area in the same time. By hue it is meant the color in the usual sense; it is hue which gives red, green, blue, etc. Tint, or purity, depends upon the amount of white admixture rather than upon the wave length, the less white light the purer is the tint. Brightness depends upon the energy of the ethereal movement and retinal sensitiveness to the particular color.

Walker (*N. E. Oph. So.*, March, 1913) states that flat, or nearly flat, test objects are preferable to spheres, cubes, or prisms, in order that they may be in the same focal plane as the fixation point, and present the same area at a constant angle and illumination.

The results of a perimetric examination are recorded upon a chart. This chart consists of a number of concentric circles, usually nine, each 10° distant from the other; and of radiating lines from their common center. The circles represent the angular aperture of the field, the lines the different meridians of the field. Beginning at the right end of the horizontal one which is designated 0 these meridians are drawn to intersect the circles at points 15° apart, and the notation runs thus clockwise about the chart. The center of the chart corresponds to the point of fixation. It is unfortunate that perfect standardization of the form and notation of perimeter charts does not exist. This would avoid confusion, and would lead to greater exactness and clearness since definite reference could then be made to the location of field changes.

To obviate the necessity of recording the visual fields on charts, and to avoid the taking up of much space in the case book, several sugges-

tions have been made relative to a new notation of the visual fields. Furthermore, the reproduction of the visual fields in journals is expensive and demands space. Armaignac (*Archives d'Ophtalmologie,* Oct., 1909) proposes that we indicate the four principal meridians—exterior, superior, interior, inferior, by the formula E. S. I. I., and the field is recorded thus: L.E. — E. S. I. I. = 90 = 45 — 40 — 50; or more simply by the tens only — E. S. I. I. = 9445.

He doubles the number of meridians measured, indicating, as an index after each of the chief meridians, the numerical value of the intermediate sector, thus: $9^6\ 4^4\ 4^4\ 5^7$ indicates that the field of the superior external meridian is 60 degrees, the superior internal 40 degrees, etc. We may further elaborate the scheme by placing another figure to the left of each of the chief figures, so as to indicate the field of the meridian which preceded the latter by 30°, that is ${}^8 9^7\ {}^6 5^4\ {}^4 4^6\ {}^7 8.^8$ The meridians are recorded clockwise in the left eye, but in the opposite direction in the right eye.

Lopex (*Recueil d'Ophtalmologie,* June, 1907) suggests a formula for the visual field expressed as a fraction, of which the numerator represents the upper half of the field, and the denominator the lower half. The meridians on the charts are numbered from right to left for both the right and left eye, and the diameters have the same number at each end except the horizontal diameter, which is 0 at the right hand side, and 180 degrees on the other.

Normal fields would be the other.

Normal fields would be recorded thus:

R. 90/60 50/70 L. 60/90 50/70

When other than the principal meridian is recorded, this meridian is indicated by the number and degree sign, and a scotoma is indicated by a minus sign. The following representing its extent from the center:

$$\text{R.}\ \frac{90-20}{60-80}\quad \frac{50-\ 8}{60-12}\qquad\qquad \frac{45^\circ\qquad 50-\ 8}{55-10}$$

When the scotomata are multiple and the peripheral field irregular the formula would become so complicated that it would be difficult to interpret unless recorded on a chart.

Priestley Smith (*Ophthalmic Review,* 1915, p. 266) suggests that the initial letter for the eye be surrounded by the number of degrees the field extends in the different directions, thus the field in a normal eye would be written:

	55	
90	L	55
	65	

or more fully:

70	55	55
90	L	55
80	65	58

These methods may be useful where details are not necessary, but are entirely unsatisfactory when the field is complicated, and an accurate mapping out of the field of vital importance. Notation of the field, therefore, by any of the methods above proposed cannot yet be seriously considered as worthy of general adoption.

In general it may properly be stated that, except for obtaining the measurements of changes occurring in concentric contraction and ring scotoma, the mechanical arc perimeter has been tried and found, in many respects, wanting and for the following reasons: It cannot be depended upon for defects approaching the center of the field, an area where definite information is often the most desired. It is time-consuming, and lastly, as pointed out by Walker, "There is no means of taking all color reading rapidly in the same color-phase time, without, in changing the colors, giving the patient some clue that a change has been made;" therefore, for detecting and accurately mapping out small defective areas in the field of vision we must resort to the practice of scotometry.

The writer finds that with self-registering perimeters it is a necessary precaution in the interest of exactness to check off the recording apparatus, and the position of the test object, on the perimeter arc. If not correctly adjusted or constructed the two do not agree and the results are thereby unreliable. The same care must be observed in all purchased test objects, 10 mm. test objects frequently meaning 9 mm.

Williams (*Lancet*, Aug. 19, 1911) describes a method for testing the color-fields without the use of a perimeter. The patient sits with his back to a good light looking fixedly at a point in the distance. He is then directed to signal as soon as he perceives any movement. The visual field is then approached by the observer's hand, which holds alongside and parallel two objects colored of an intense, pure, bright red and blue respectively. After the patient signals he is asked to signal again as soon as he perceives any color, while the center of the field is very slowly approached. The observer then stops the movement and asks what color is seen. To corroborate, the movement is then continued until the other color is seen.

So far the limitations of the visual field have been under consideration and it may be justifiable here to refer to a method of testing the visual power of the peripheral portions of the retina, that practised by Groenouw (*Arch. f. Augenheilk,* Bd. XXVI, 1892). The Groenouw method is designed to test the visual minimum and form-sense of the retina. To test the former he uses a white card 6° wide, with a small black dot in the center, which is moved centripetally along the arc of a perimeter until the presence of a black mark is recognized by the patient. The recognition of the black spot on a white background is not a function of the light sense, as considerable variations and contrast between the object and the background make very little difference. The spots used vary from ¼ mm. to 4 mm., and the lines joining the points where each spot becomes visible are called "isopters" and run almost parallel to the limits of the field of vision. The examination of the field by this method often demonstrates defects which are not evident with the ordinary methods.

(4) *Scotometry.* Within recent years several modifications of the ordinary methods of taking the visual field have been introduced for the purpose of getting a more exact knowledge of the functional activity of the retina, optic tracts, and visual centers. These modifications of the old methods have to do, in the main, with improvements in the illumination, the size and character of the test object, variations in the distance between the patient and the screen, and many other means to insure more accurate fixation of the test object during the examination.

Bjerrum (*Nordisk Ophthal., Tidskrift,* Vol. 11, p. 3) in this and later communications, has proposed a method that has found favor in ophthalmic practice, and has to no small extent made its influence felt. By this method small scotomata are projected on a large screen, facilitating their discovery and definition and bringing out, oftimes, slight alterations in the field which occur in the early stages of glaucoma and which are of great diagnostic and prognostic importance.

In arc perimetry the test objects usually employed subtend an angle of two degrees to four degrees, and thus cover a large area of retinal elements. This gives a rough test compared with the tests for visual acuity. While the shortcomings of arc perimetry were realized, and the blackboard tests of von Graefe, de Wecker and Joy Jeffries were resorted to in defining scotomas in the fields, it was not until about 1889 that Bjerrum brought to our attention a method of accurately defining these defects upon a black surface.

The maximum extent of the visual field is obtained only when the test object is perceived within a visual angle of ½° or more. When

the test object is reduced below a size which gives a visual angle of less than ½° the extent of the field is directly affected.

In Bjerrum's method the test objects employed are smaller than the size which is required to get the full field, i. e., the field taken on a perimeter of the usual type, and in the ordinary way. The defects discoverable by Bjerrum's method, with the small test objects, are regarded as ''relative'' since, when one uses a larger object in these areas, vision can be excited.

Fleischer (*Klin. Monatsbl. f. Augen.,* July, 1913) uses a blackboard. Bjerrum, on the other hand, as stated, uses a screen. Fleischer calls attention to the value of this method in the study of glaucoma. Bjerrum proved that the glaucomatous field of vision did not show the earliest changes in the periphery, but in the region of the blind spot, which Fleischer confirmed. It is now clinically proven that the scotoma in glaucoma is in connection with (enlargement of) the blind spot. This Bjerrum attributes to an elective affection of the optic fiber.

Application of Bjerrum's test. The method of applying the Bjerrum test is as follows: A large black screen, two meters or more in width, is suspended vertically, in a good light, at a distance of two meters from the patient. The test objects used are small discs of white ivory, or stiff, unglazed, white paper, from 20 mm. to 1 mm. in diameter, carried on a long, reflexless, and very slender, black rod, with a spring clip at its end to hold the test object. The fixation spot is designated by a small piece of gray paper, the smallest the patient can see comfortably being chosen. The fixation spot is placed in the middle of the screen, which admits of testing to about twenty-seven degrees from the point of fixation. When a larger test object is used the fixation spot may be placed nearer to the margin of the screen.

The surface of this screen is outlined with fine black cord, or thread, in radiating lines at intervals of 15°, and circles at intervals of 50 mm. These markings enable the examiner to transfer the tracings to a perimetric chart simply by reference to a logarithmic table.

As this test is one which has received, and is receiving, so much attention by the profession, it is perhaps permissible to quote, practically in its entirety, a description of an apparatus which Sym and Sinclair have set up. (See *Ophthalmic Review,* 1906, Vol. 25, p. 141.)

For use in the hospital consulting-room they have found it best to have a large screen constructed, consisting of a light but firm square of wood measuring seven feet across. This is mounted vertically upon feet provided with casters, after the manner of a school slate or board; it can thus be readily brought forward into the light from a large window—for the test should be conducted in good daylight—and when

not required can be pushed aside against a wall. Across this screen is stretched a square of velvet, which is slightly larger than the wooden frame, around the edges of which the velvet is brought and firmly tacked down; thus no fastening, glittering nails or what not, can be seen from the position of the patient. Should the frame require any crossbars to support it, these are so placed that they do not touch the velvet at all; the purpose of this arrangement is, first, that they may not "show" through the velvet and so cause differences in the intensity of the black background, and second that they may not interfere with the introduction of the recording pins. The screen must almost reach the floor, that no troublesome light coming from below it may interfere with the test, and the feet are painted a dull black for the same reason.

The velvet must be of good quality, not "thin," lest light come through its substance, and lest its color be not equal throughout, and it must, of course, be a pure and rich black, neither purple-black nor brown-black, but the "deadest" possible. Of material 18 inches wide, about 12½ to 13 yards are required, and care should be taken that when the lengths are sewn together the seams should, so far as possible, be invisible. It is unsuitable to have black threads permanently fixed in front of the screen to mark the meridians or the concentric rings, as these threads become quite visible after a time against the velvet and as they also get in the way of the traveling test object. They have, therefore, adopted the following plans: First, as regards the meridians: they settle the permanent fixation spot, which should be at the center of the screen, and measure out from it the various radii at 15° intervals all round. At the very periphery of the screen each of these meridians is indicated by a black velvet button sewn on; these are not sufficiently visible when at the periphery to give any trouble whatever. Next as regards the concentric circles: if one marks them off in any way, then the screen can only be used for one fixed distance (say two meters), whereas it is convenient at times to use the test at one meter, when vision is less good, or for some other reason. They, therefore, devised a flat rod marked on one side with the tangents showing the various degrees of separation at 1 m. and on the other side with those of 2 m. Once the needful calculations have been made, it can be constructed by any skilled maker of instruments. The precise method of use will be seen presently.

The test objects employed are those of Bjerrum himself—discs of ivory of certain fixed size, each mounted on a fine stem. This stem fits into a slit in the end of a black metal carrier or pointer, which is used to move it here and there over the screen. If one prefers to do

so, he can, in place of these employ a flat rod covered with the same velvet as the screen, and discs of pure white paper. Charts of the field much larger than the usual size have been prepared showing the normal dimensions for various sizes of test objects and ready for marking off as the patient is tested. It is impossible, accurately, to mark in these details upon a chart of the usual size.

It is well, also, to have a head-rest fitted up, with an excursion of at least a few inches, so that whatever his height the patient's eye may be in the same horizontal plane as the fixation spot. The one which the authors named actually employ resembles that of a Kagenaar's ophthalmometer, but the side pieces are curved back slightly, so as not to be visible to the patient himself. It stands by the side of the patient's chair, underneath which one of its three feet passes; the actual headpiece is at the end of a horizontal arm.

Velvet gathers specks of whitish dust so readily that it is well to keep the screen covered. The method employed is to have a black linen square, rather larger than the screen, fastened along the top bar behind; from there it hangs over the front of the screen, and is weighted at the foot. When the screen is to be used this is turned over to hang at the back, where it reaches down to the floor, still further obstructing any possible light which might come through or below the velvet.

In actual practice the points of appearance and disappearance of the test object are marked out on the screen by means of black-headed pins, thrust in at the point of demarcation, wihout any reference either to meridians, of angular separation from the eye, or to the radii of the screen. When the scotoma has thus been marked out, the flat rod above mentioned is taken and in a moment, as it is laid along the various meridians indicated by the peripheral button, one can read off on it the angular separation of each pin from the fixation object and prick it off on the chart. Care must, of course, be taken that the side of the rod be utilized which bears the scale corresponding to the distance separating patient and screen.

Certain surgeons take exception to Bjerrum's screen test on the rather unsatisfactory ground that an examination by its means takes too long, Sym and Sinclair's experience is that fifteen or twenty minutes, or even much less when one is accustomed to the method, will enable one to come to a definite conclusion in any given case.

A modification of this screen for use in a private consulting-room where space is more precious, is to have a square of velvet of two (or three) widths, which can be rolled up like an ordinary window blind; this hangs from a horizontal rod. When the screen is so narrow it is

almost necessary to have two alternative fixation spots, one of which is shown and one concealed, to suit the right and left eyes.

Such an arrangement gives quite a good clinical test of the presence or absence of the important scotoma, even if it may lack the scientific precision of the more elaborate large screen.

It is to be noted that the average normal field taken by Bjerrum's method, and projected on an ordinary perimeter chart, is much smaller than the fields obtained under usual perimetric tests, that is with 10 mm. test objects and at a distance of 30 cm. under which these tests are made.

Sinclair (*Trans. Ophthal. So. U. K.,* 1905 p. 38) gives the following average dimensions of the field for white when test objects of 6 mm., and 3 mm., and 1 mm. are employed at the usual distance of two meters.

	Out.	In.	Down.	Up.
$\frac{6}{2000}$	50°	40°	40°	35°
$\frac{3}{2000}$	37°	30°	30°	25°
$\frac{1}{2000}$	26°	26°	25°	24°

The blind spot measures about seven inches in diameter, and is surrounded by an amblyopic zone having an irregular and less well-defined extension in its upper and lower poles, which correspond to the position of the trunks of the large blood vessels leaving the discs. If the field be taken in reduced light no marked changes are noticeable in its extent, but defects are accentuated.

Holloway (*Trans. Am. Ophthal. Soc.*, 1911), submitted a new stick to be used in making these tests. This he describes as follows: In the center of this stick there is a fish-pole joint, and near the proximal end a concave surface for the thumb, while the distal end is provided with a thum-screw similar to that used on a universal handle for laryngologic mirrors. To this is attached a fine wire on the end of which is a small cross. Another wire is also provided, which is tipped with a small cylinder 2 mm. in diameter. For test-objects gummed discs having a diameter of 1, 2, 3, 5, and 10 mm. As a rule, no difficulty will be found in having the large test-objects remain perfectly flat

when used on the smaller tip, but the wire tipped with the cross will absolutely prevent any curling of the paper.

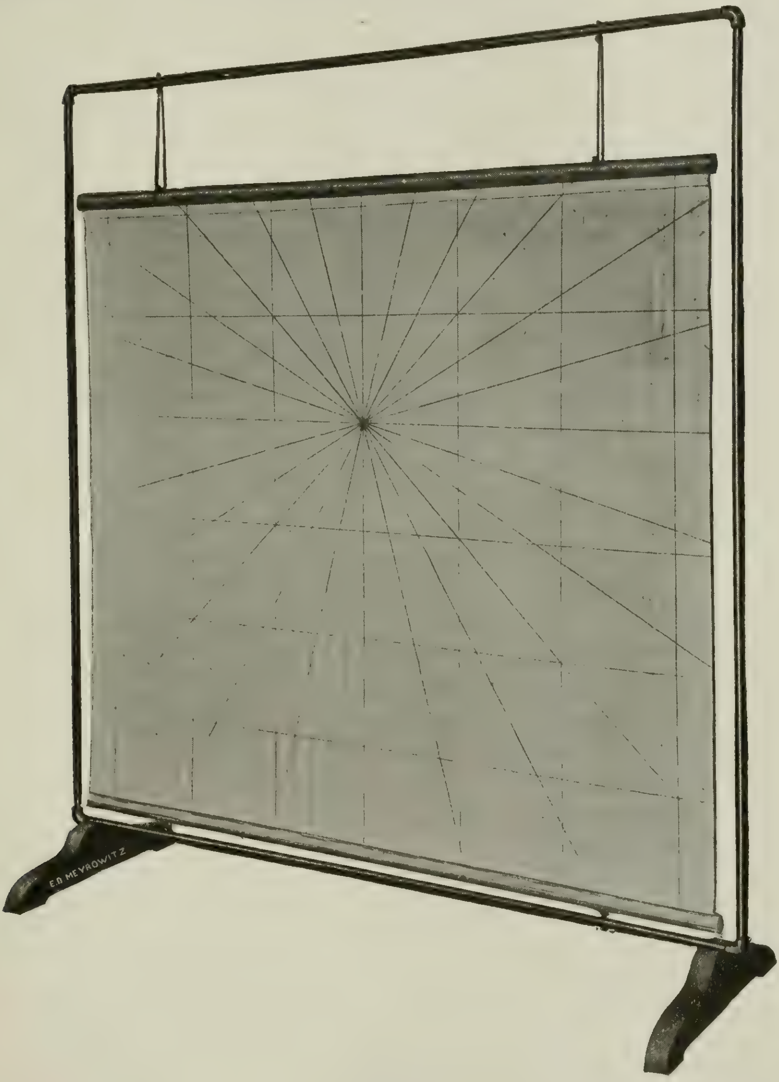


Fig. 18.
Bjerrum Tangent Plane Screen After Model of Alexander Duane.

The accompanying figure illustrates Bjerrum's screen after a model proposed by Duane. The apparatus consists principally of a screen or chart, approximately 6 feet square and mounted on a stand in a way to permit its being raised and lowered as may be required.

The side of the screen presented in the illustration is actually the back. The front of the screen, or that part presented to the patient's view is black. The screen is used in the following manner: The patient is seated before the black side at a distance of 30 inches, and the screen is adjusted so that the center is on a level with the patient's eye. A central fixation point is established with a small piece of paper cut to the desired size, depending on the work to be done; the black side of the screen being made of felt, such small paper squares adhere readily without being secured. Color objects, as ordinarily used on the perimeter, may be used for exploring the field, and the limitations are readily marked by white millinery pins in mapping out form fields, and correspondingly colored pins when mapping out colored fields. These pins, projecting through, show their locations on the graduated side of the screen, and these positions are readily transferred to charts printed for this purpose.

Modifications of Bjerrum's method. The fact that the screen used by Bjerrum is of some considerable size and demands suitable space, which may cause inconvenience in ordinary consulting rooms, has caused certain small pieces of apparatus to be made for making this test.

The scotometers of Priestley-Smith and Bardsley. The first of these instruments consists of a disc 39 cm. in diameter, which is covered on its front surface with dull-black cloth, and marked on the back with the degrees of the circle. The 5°, 10°, 20°, 25° circles are indicated on the cloth surface by small black knots, not perceivable by the patient, but easily felt by the surgeon. The fixation point is the screw which holds the disc to the vertical stand. This disc rotates about a screw when the test is applied. From each side of the disc is a wire which converges to meet a like support from the other side, and both are attached to a knobbed handle, which is held against the cheek during the test. The test is made by sticking a 2 mm. piece of thread or blotting paper on one of the knots indicating the degrees from the center and starting with the pointer at the zero of the circle scale. The disc is moved in the direction of a natural sequence of the numbers on the scale, while the patient continues to fix the center screw. The process is repeated with the test object applied to the other knots on the screen, and even on intermediate points, if necessary.

Smith (*Trans. Ophthal. So. U. K.*, Vol. XXVI, 1906, p. 215), states that if the test object does not disappear or dim in the 25° circle, glaucoma is probably to be excluded as it indicates no defect extending from the blind spot toward the periphery, however, as the defect in glaucoma sometimes extends from the blind spot toward the fixation

point, it becomes necessary to test the 10° circle as well as the 25° circle. If there be no defect in either circle, there is no glaucoma.

The construction of the Bardsley scotometer consists in a large part of a section of a hollow sphere mounted on three small wheels in a frame so that it may be revolved about its own center.

In the center of this section, corresponding to the fixation point, is a small opening. Extending from this opening to the edge is a narrow slot. Through this slot the object is moved and a scale, parallel and

Fig. 19.
The Bardsley Scotometer.

close to the slot, shows the angular movement of the object in degrees from the center. A circular scale surrounding the hollow section shows the position of the slot whether vertical, horizontal, or at any intermediate position. The disc is revolved about its axis by means of a friction wheel, which secures smooth rotation and without bringing the operator's hand into view of the patient.

In using the instrument the patient faces into the dull-blacked section of a hollow sphere—a miniature Bjerrum's screen—with a central fixation disc. There is nothing moving besides the test object; no carrier to reflect the light or to make a noise, nothing to distract the patient. Through the fixation spot of the spherical section there is a minute hole. Through this the surgeon can watch the eye of the patient continuously and can immediately allow for the slightest deflection on the patient's part. This has advantage of the Smith scoto-

meter in that the exact shape and size of the scotomata may be more quickly and accurately mapped out.

Besides these scotometers are to be noticed an apparatus devised by Haycraft. (*Journal of Phys.*, Vol. 50, No. 6. August 15, 1910). In this apparatus the screen is a black metal plate over which a nail bearing a white or colored test object can be made to travel in both vertical and horizontal directions. Haycraft uses this apparatus to show that at the margin of the blind spot all colors appear gray, that is,

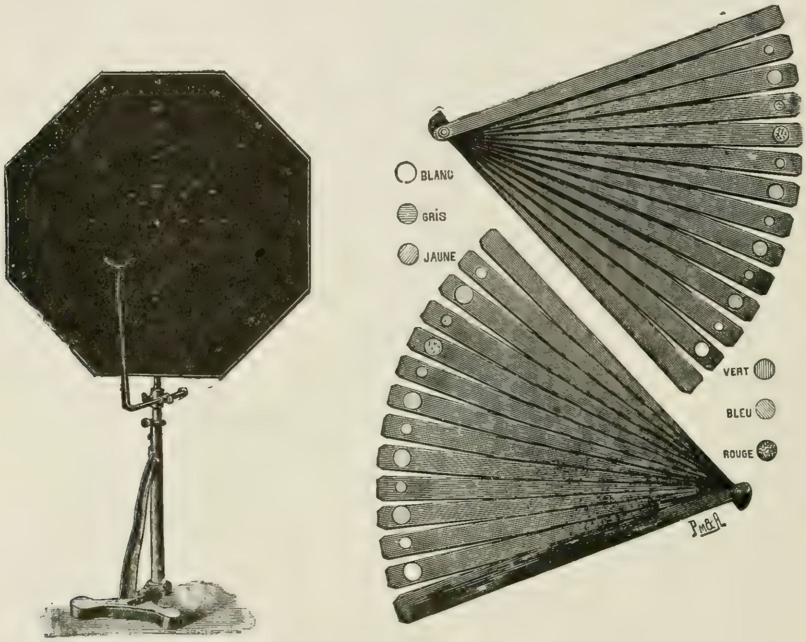


Fig. 20.
De Wecker's Campimeter.

that at this area color-blindness exists. As they are moving away from this area during this test the colors become recognizable in the following order; blue, yellow, green and red.

Holth (*Annales D'Oculistique*, Sept., 1908), proposes a rough test for simple scotoma. The red end of a dampened match may be used as a test for scotoma for red. He sticks one match vertically into the partially open end of a match box, and two others, with their heads in the same horizontal line as the central one, are fixed obliquely in each corner of the same box. He has the patient fix the central match and note the color and comparative brightness of each match head to discover whether the scotoma is central or para-central. The informa-

tion obtained by this test is too indefinite to be of any considerable value.

Many excellent pieces of apparatus which possess accuracy, and are light and portable, have been devised, and among these is the campimeter of de Wecker. See fig. 20.

This instrument is used for examining the visual field where precision is required, in connection with the fan of Bouchart. De Wecker states the examination of the visual field cannot be made in a complete manner without the aid of a certain number of small surfaces, white

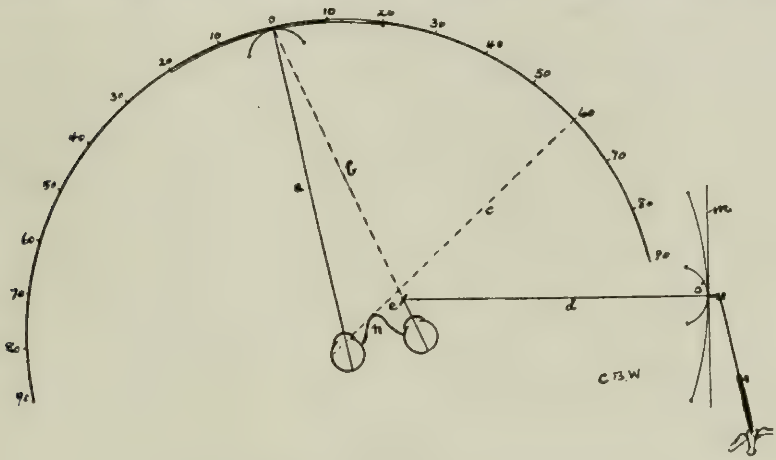


Fig. 21.
To Illustrate Walker's Method in Imperfect Fixation.

or colored, and of various tints and sizes, but clearly defined in regard to the color and dimension. The four colors he uses for study correspond to the retinal lesions, or to the optic fibers and are here represented each by four tests of different diameters. The same number are used for the tints of white and gray necessary for a study of the defects of light sensation both central and peripheral. The surfaces of the test are 100 m/mq, 50 m/mq, 25 m/mq et 5 m/mq permitting great precision in the tests of small lesions of the field and particularly for central scotoma. The colors are red, blue, green, yellow and gray. All the needed elements are united, thus avoiding a confusion in a single apparatus which is both simple and convenient. The fan is. of dull-black wood of slight incumbrance both as to weight and size.

The Umbrella Test. Walker (*Arch. of Ophthal,* Vol. 46, No. 6), Reber and others have used an ordinary umbrella with a radius of 1000 mm. This umbrella is supported on its convex side and lined with a black material. The inner surface of the umbrella is marked off about

the center with circles at 10 degrees and radii of 30 degree intervals, being in fact thus an actual field chart. The umbrella may be used at 1000 or 2000 mm. If the latter is used one doubles the degrees in the reading.

The writer also described a "combination screen and umbrella," the larger screen being attached back of the umbrella on the same stand. The screen is 100 inches wide and 80 inches high. After correction of the curvature the markings are drawn on the screen. The available number of field degrees about the fixation point on this "combination" screen Walker gives as follows:

"At 1000 mm. 50 degrees in the vertical meridan, 60 in the horizontal; 1500 mm.—37 degrees vertical, 45 horizontal; 2000 mm.—30 degrees vertical, 35 horizontal; 2500 mm.—25 degrees vertical, 30 horizontal; 3000 mm.—14 degrees vertical, 23 horizontal."

He thinks this umbrella with combination of screen is comfortable to work at and easy of adjustment to different distances, and that the readings are readily made, and also that it will take the entire normal field for 1 mm. disks with accuracy to a high degree.

Methods practised in taking the field in imperfect fixation. When central vision is affected and fixation, thereby, defective, the discovery of errors in the visual field, and their charting, is one of more than ordinary difficulty, or quite impossible. The methods employed to overcome these difficulties consist of the first place in exposing the test object for such a short period of time that the eye has little time to wander, or, what is better, in using the perfect fixation of the sound eye to control the defective one. In most cases defects of this character are monocular, or at least the trouble is not so severe but that fairly useful fixation remains in one eye.

Walker's method with the macular selector. Walker (*N. E. Ophthal. So.*, March, 1913), uses an instrument (see Fig. 12) called the combination blinder and macular selector. The blinder is provided with an opening on the nasal side of the shield, which is at such a place that when the eye to be examined is in the proper position on the perimeter, the other eye with normal fixation may be able to fix at the fixation point of the perimeter through this opening. This opening is provided with a light-tight shutter.

As stated previously, this part of the instrument may be used as a simple blinder in taking the fields of eyes with normal fixation. In eyes with abnormal fixation this shutter is opened before the normal eye, and one of two attachments may be fastened over the opening in order to obtain fixation from the covered eye.

The first, and simplest, of these is a conical tube about two inches

long with an opening of about 2 mm. in the small end. The patient sees an area of about 1 sq. cm. about the fixation point of the perimeter. The base of this tube is fitted with a sleeve which when clamped to the blinder brings its base against a spring thereby rendering it easy to move the tube in a limited ball-and-socket fashion, but once adjusted is held by the spring in this position.

Walker suggests in such cases that before making the test the patient be given the tube alone, and be directed to look through it at very small fixed and moving objects, and that this brief exercise assists greatly in finding and fixing the fixation point on the perimeter while making the test.

The second attachment resembles somewhat a retinoscopic mirror mounted in such a way as to move in any direction about the center of the mirror and which is also provided with the sleeve that fits closely over the shutter of the blinder shield.

The opening in the mirror is further provided with a small shutter, which may be used to cut off direct observation of the perimeter. On one end of the mirror axis is a thumb screw controlling movements of the mirror. The patient may practice in taking the mirror and noting how an object at one side may be reflected into the eye while at the same time he is able to see objects straight ahead through the opening in the mirror, and also parts of the objects in the unaffected field in the other eye. When by adding one image after the other all three may be seen and superimposed at will, we may proceed to the perimetric arrangement represented in the figure, which is drawn to scale.

The method is described by Walker as follows: The eye to be examined is placed at the center of the perimeter. The combination blinder and macular selector (mirror attachment) is then arranged over the other eye and will be found to lie entirely behind the shadow represented by the line (c) on the nose (n). See Fig. 21. With the mirror placed vertically at right angles to the line of vision, the patient then locates the center of the perimeter (o) through the opening in the mirror while the other eye is kept closed. The mirror is then slowly rotated, while the patient remains fixed on the center, until the secondary spot (o′), which has been placed approximately in the correct position, is seen. To aid this adjustment, if at any time either object disappears for any reason, it may be readily found again by holding a dark card so as to cut off the visible object until the other object is found.

In this way and by fine movements of the mirror or of the stand supporting the secondary fixation point (o′) the latter may be very

quickly superimposed on the central fixation point (o). At this stage the eye to be examined may be uncovered and if no muscular imbalance or fusion suppression interferes, the field may be at once taken. Of course, the distance of the secondary fixation point (o′) and the distance of the primary fixation point (o) from the center of the mirror (e) must be equal. That is (d) must equal (b), in order that the two fixation objects may appear of the same size and be seen with the same accommodative effort.

A very considerable aid in effecting these adjustments, as well as for testing the condition of the fusion ability, may be found in a certain arrangement of the fixation points. Two right-angle crosses are made of stiff wire. The arms of equal length are bent to the same curvature as the perimeter arc and soldered together at their middle points, which are also the fixation points. At these points may be placed a small capital letter, "A" for instance, since better fixation may be obtained by having something more definite to look at than a black spot. The wire ends may be tipped with small balls to make them more noticeable, though, of course, it is not necessary. Another helpful, but not absolutely necessary thing, is to color one cross differently from the other. Complementary colors may be used which will give their characteristic color phenomena on superimposing them. Perhaps the most satisfactory arrangement is to use a white cross on the secondary fixation point (o′), and a yellow or other color not used in the examination for the primary fixation point (o) cross. Either or both crosses may be removed from the fixation points or left during the examination, after fixation has been established, and may again be replaced if necessary for again testing fixation. They may also be rotated to any position most suitable to the particular form of the field being examined, though usually they are used in the horizontal vertical position. One can do very well without the use of crosses at all, or narrow adhesive strips may be quickly laid on the perimeter and on the black disc (m) surrounding the secondary fixation point (o′).

Hess' method (*Arch. of Ophthal.*, Nov., 1905). Hess' method is based upon the theory of exposing the test object such a period of time that the eye does not wander. He describes this method as follows: Little white discs arranged in regular rows on a black ground are made visible by momentary illumination. One or more of the discs can be made visible by covering them with black paper. The patient is placed at such a distance that a smaller or greater number of the discs will be pictured on the region of the retina undergoing examination, and has to state whether, at the moving of the shutter, all the discs are visible or not, how many are absent, and what are their

respective positions. If this experiment is repeated several times and the patient always gives correct answers, a scotoma can certainly be excluded from the area under consideration. If, in an investigation, the white disc, whose image would fall on the blind spot of a normal

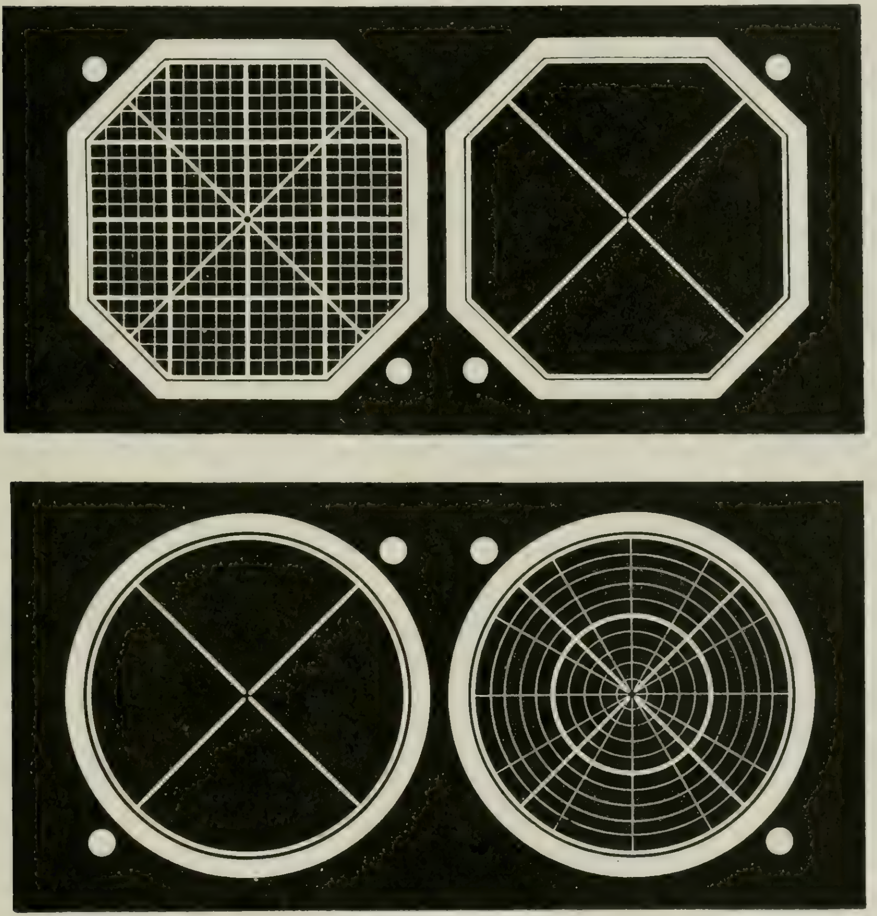


Fig. 23.
Haitz's Stereoscopic Cards.

eye, be covered, the patient cannot see that it is covered and makes a false statement if he tends to complete the picture. Every normal eye has, at a point corresponding to its foveal region, a blind spot with a sufficiently lowered illumination, and a relative scotoma when the illumination is less lowered (lessened foveal sensitiveness of the eye adapted to dark). If 16 or 25 little white discs are arranged in four

or five rows of 4 or 5 each, on a black background, at a satisfactory distance apart, and placed at such a distance from the eye that the image of one will fall on the entrance of the optic nerve, that disc will appear absent from the row, the pattern will appear defective and will not be completed. The same will be found true of the foveal scotoma by reduced illumination.

Haitz's method with stereoscopic cards. Haitz (*Klin. Mon. f. Aug.*, Oct., 1904) uses cards on which are drawn geometrical figures in silver gray on a dark background. Small discs placed above one figure and below the other enable the surgeon to determine whether binocular fusion is complete for small central scotomata.

The figures (23) consist of circles with diagonal lines which are interrupted by a central hiatus on one side and on the other by a white, or colored, spot.

The figures are octagonal, the peripheral charts being in thick gray lines; diagonal and degree lines being less intense. Lines indicating degree are only drawn on one of the figures and this is placed in front of the eye to be examined.

These cards are placed in Holmes' stereoscope, and the field is taken in the usual way, test objects being 1¼ mm. 2 mm. square, and the holders the size of the needle. Heidelberg colored paper is used as the test object.

Schlösser method. Schlösser (*Vossiussche Abhandl.*, Bd. III Heft 8) bases his method on the principle that "if one eye be covered with a red glass, then this eye cannot recognize a properly selected green, i. e., its complementary color; in the binocular field, where green is recognized, it is done by the uncovered eye." (Hirshberger.)

The field is taken on an ordinary perimeter, the fixing eye is covered with a red glass and fixes a green center spot which will appear black; the test object is green (the complementary color to the glass over the testing eye). If the eye at any point of the arc fails to see the green color clearly there is in this corresponding region a relative, or absolute, scotoma for green. The examination is repeated for each fundamental color. With white test objects absolute scotoma assumes a red color, and a relative scotoma when it assumes a gray color. Schlösser states, for correctness, it is necessary to work with a moving object to avoid local adaptation.

Tomlinson's test. In the instrument devised by Tomlinson (*Trans. Ophthal. So. U. K.*, Fasc. 2, vol. 30, 1910, and also *British Med. Journal*, Vol. 12, 1909, p. 985) the test object used for exploring retinal defects and testing the retinal function consists of the image of the spot used as the fixing point of the eye, reflected in the mirror

hinged near the eye in a closed casing, having at one end an aperture for the eye under test to look through, and at the other end a plate pierced with a small hole, which is directly visible, and serves as a fixing point for the eye.

The other eye has also its fixing point of the same size and both these are fused into one, giving stereoscopic fixation. An image of this small hole is reflected from the mirror in any position. By holding the casing stationary, and moving the mirror, the reflected image moves over the retina; and by leaving the mirror fixed at any given angle and rotating the case, the reflected image may be caused to describe a circular path over the retina. By doing this in the 15°, 20°, 25° and 30° circles a thorough test can be made, and this can be controlled by varying the size of the aperture and the light.

To test the color fields, Tomlinson uses small plugs fitted with colored gelatins inserted in the light aperture on the chart plate. Connected with this apparatus is an automatic registering appliance for notation of the fields on a chart.

Joseph-Pigeon method. Joseph (*Recueil d'Ophtal.*, 1907, p. 641 and *Arch. d'Ophtal.* Feb., 1908), uses Pigeon's stereoscope consisting of two planes of wood hinged together and set at an angle of 140°, and a third plane connected with and bisecting an angle Evans (*Ophthalmoscope,* Oct., 1911), describes this as follows: On one side of this central plane and near its upper part is a small triangular plane mirror (M) in which the chart, affixed to the surface of one of the outer planes, is viewed by one eye when the apparatus is in use. The other chart, affixed to the inner surface of the second lateral plane, is viewed directly by the second eye. The charts are similar to those used in ordinary perimetry, but have only the eight principal meridians marked, so as to aid fusion. The lines are gray or reddish-brown on a black background. Scotomata are mapped out by means of small white or colored test objects on a black-handled carrier. In cases of deviation of the optic axis, the charts can be moved until fusion is attained.

The point of fixation can also be displaced, so that more eccentric zones may be explored. The ordinary commercial form of the stereoscope ("Dixio") allows of exploration of the field up to 25° from the center. The illumination of the charts can be varied, so that fusion is assisted in case of unilateral amblyopia, and so that a relative scotoma is made more easily appreciable to the patient.

Von Szily's method. Von Szily, in a method fundamentally not unlike that of Walker, secures fixation of the eye by the use of a funnel-shaped tube which he attaches in the proper position to a perimeter.

The better eye fixing through the tube with all but central vision excluded.

Jackson's method. Jackson recognizing the difficulty of obtaining the field in imperfect fixation arranges a series of concentric circles on a piece of paper, each successive circle having a radius say one centimetre greater than the circle next within it. The patient is told to look at the center of these circles which are held at such a distance that the image of the outer circles falls beyond the region of the scotoma so that the circumference of this circle is clearly perceived throughout. Should the scotoma be exactly circular one ring will be visible beyond it, and the next smaller ring will be invisible within it. When the scotoma is oval with the long axis horizontal, some of the circles will be seen above and below, although the lateral portions are hidden. With the aid of this arrangement fair fixation can be obtained and a scotoma satisfactorily mapped, although it involves the fixation point.

Claiborne thinks that when patients are intelligent it is well to get them to draw their own fields, particularly in cases of scotoma. He thinks it is the truest expression of the field, when the patient is intelligent.

(5) *Exceptional methods.* Heretofore we have dealt with methods for taking the visual field in cases of the mentally alert, and with certain unusual methods in patients with more or less defective fixation.

The latter class of cases are obviously difficult but the several methods described contribute much toward obtaining a fairly accurate field even in such cases of imperfect fixation. We must now, however, consider methods for obtaining the visual field in those cases which are not mentally alert, and even actually defective owing to the disease or accident. For example, in cases of sensory aphasia, in the somnolent, or semiconscious, in the mentally weak, as in certain paralytics or apoplectics, or further, in certain cases which have sustained injury, we must, if information is to be had relative to the fields, resort to unusual tests.

In the bed-ridden it is difficult, or impossible, with the ordinary perimeter to take the visual field. In many of these patients we find the intelligence is not affected, and it is possible, by supporting them in an upright position, to get very satisfactory results with the hand perimeter of Schweigger (See fig. 24) and also that of Dana. (See fig. 27. These instruments are light, well-balanced, and have all the essential parts of an ordinary perimeter.

In certain cases, where these instruments are impractical, the bed-perimeter of Wilbrand may be used advantageously.

Fig. 24.
Schweigger's Hand Perimeter.

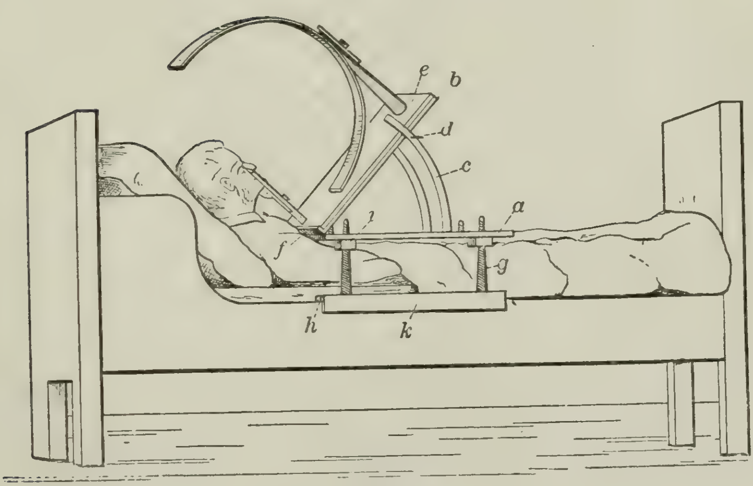


Fig. 25.
Wilbrand's Bed Perimeter.

By reference to the figure (25) it will be seen the apparatus consists essentially of a table "a" fastened to each side of the bed, and with adjustable screws permitting elevation of, or lowering of, the apparatus. A second board "b" holds the perimeter and this being on hinges connected also with the table permits of its being placed at different angles through its supporting iron, and by adjustment of the iron pin "d" which is held at the different perforations of this sup-

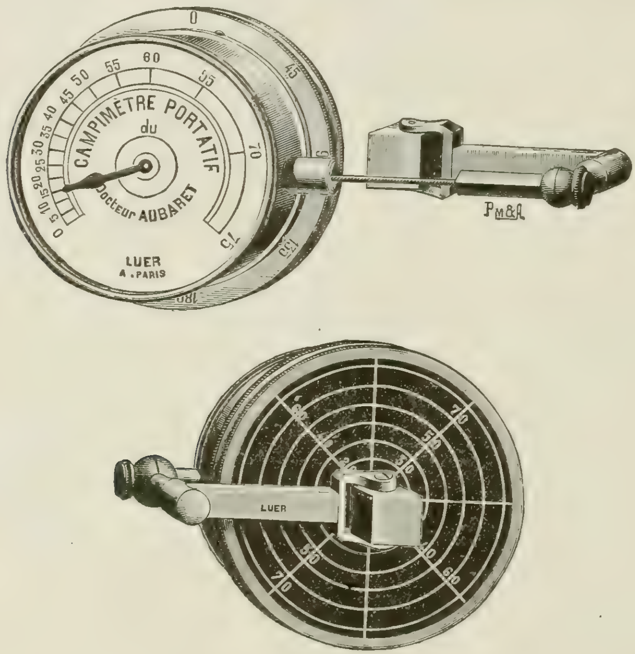


Fig. 26.
Aubaret's Campimeter.

porting iron "c." In all of his own practice, both public and private, the writer has really found very little occasion to use such a perimeter.

A very elegant and convenient instrument for the bed-side is the campimeter devised by Aubaret, of Bordeaux. (Fig. 26.) This instrument is exceedingly small, and, therefore, easily portable. This being used with the patient in any position, the examination of the field can be made very rapidly, which is an important matter when dealing with the class of cases now under consideration.

The apparatus is placed at 15 cm. from the eye to be examined, and held in one hand, while, with the other, the white or colored mires are drawn through each of the meridians of the visual field. The

needle upon the dial indicates exactly the value of the angle, and the extent of the field in the meridian under examination. It is very easy to arrive at a marked degree of precision with this ingenious apparatus.

The different points indicated by the dial are transferred to a chart as with the ordinary campimeter.

Dana's pocket perimeter is also an excellent instrument where size, portability and convenience in application are desired. (See fig. 27.)

In cases of sensory aphasia, in paralytics, or apoplectics, we make use of the so-called "winking reflex" for the determination of defects in the field. This test is carried out in the following manner: A light is carried from one side toward the field of vision, and the ex-

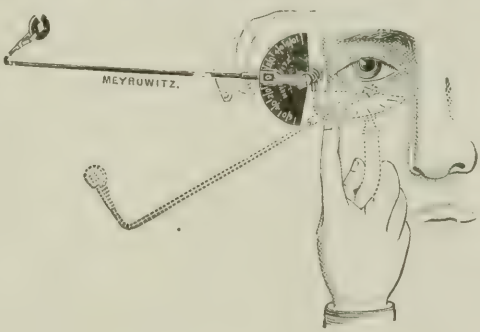


Fig. 27.
Dana's Pocket Perimeter.

aminer notes as this is brought toward the center of the field if there is a reflex closure of the lids. As the field is reversed, the outer field corresponds to the inner retinal areas, and vice versa. The half of the field indicating function corresponds in its position to the non-functional half of the retina, e. g., absence of reflex in the temporal field only indicates an abnormal nasal and a normal retinal area.

Walker (*Ophthalmic Record*, Dec. 1917) calls attention to the necessity for using at certain times exceptional methods in the carrying out of perimetric examinations of neurological cases. Many of these cannot leave the bed; some cannot be raised from the pillow. The apparatus devised is one to imitate daylight illumination, and is adjustable to practically all positions to meet the needs of the different cases. The method has the further advantage that the field may be taken at any time, either of the day or night. This is clearly advantageous in those cases where a field must be taken in a mentally lucid period.

Two conditions must be fulfilled; first, there must be an apparatus adjustable to all positions of a patient confined to bed; second, there

must be artificial illumination of such an apparatus that is easily controlled. Walker describes his apparatus as follows:

"The perimeter is suspended from a carriage (See fig. 28) which is underslung from two rollers (a, a) traveling along the upper surface

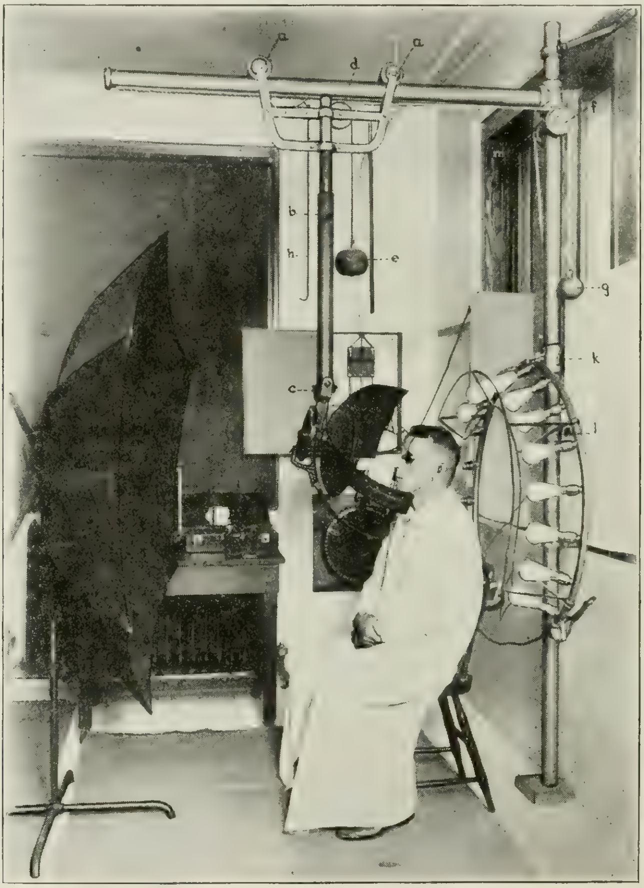


Fig. 28.
Walker's Adjustable Apparatus.

of the projecting arm of the crane. The carriage and the perimeter are connected by two telescoping pipes (b) which can be clamped together. This telescoping tube provides movement along and rotation about the vertical axis of the perimeter. At the lower end of the outside telescope pipe is a ratchet joint (c) to which the perimeter is clamped below. By means of this joint the perimeter can be tilted

through an angle of 90 degrees from the vertical corresponding to an angle at which the patient reclines.

"In order that the horizontal motion of the carriage on the crane and the vertical motion of the telescoping pipes can be smoothly controlled, counterweights are used thus: Two cords inside the telescoping pipe are attached to the lower segment just above the ratchet joint. These cords, emerging at the top of the upper segment, pass over a pulley (d) which projects into the pipe through a slot. One of the cords then passes directly downward again to attach to the larger counterweight (e), while the other passes along the horizontal arm of the crane and over another pulley (f) on the upright pipe, and thence down to the smaller counterweight (g). The sum of these weights is equal to the combined weight of the perimeter and the lower segment of the telescoping tube. By this arrangement the smaller weight (6 pounds) not only acts as a counterweight for the perimeter but also pulls the carriage slowly along the crane toward the patient, if the trigger (h) is depressed. This motion can be checked at any point by releasing the trigger (h), which allows a dog to escape in the notched strip of channel iron fastened to the under surface of the crane. The strip of channel iron also serves to prevent lateral swinging of the telescoping tube, the latter being grooved at its upper end to receive the projecting margins of the channel iron."

Where there is marked suspension of cerebration, or when dealing with children, or even with some adults, a bright object held before the eye may attract attention and thus cause fixation. Another light is then moved in from the periphery and the point noted where attention is diverted. In this way defects of considerable degree may be disclosed and thus afford some practical information, taken together with other signs, as to the location of such a growth. Occasionally large squares of white or colored paper may be used in the above described test.

The so-called "light projection" test carried out in cataract is none other than a test of the functional activity of the retina, or in other words of the visual field. In this test we use the dark-room and the patient is seated in front of a light whose rays are reflected from different positions by a mirror. If we have no disease other than the opaque lens light is quickly perceived at all points of the field. By varying the intensity of the light back of the patient you may gain considerable information, not only as to the extent, but degree, of the retinal sensibility.

In certain of our large railway systems an attempt has been made to ascertain the extent of the visual field for color and form, especially

the former, under actual working conditions. These tests have disclosed that, as a rule, the outdoor night tests indicate for color the same conditions that have already been elicited by the usual examinations with the Holmgren and lantern test.

CONTOUR, POSITION AND NOMENCLATURE OF CHANGES OCCURRING IN THE VISUAL FIELD.

Contour. The different forms in which defects in the visual field occur may be considered under three headings:

(1) Concentric contractions.
(2) Sectorial defects.
(3) Scotomas.

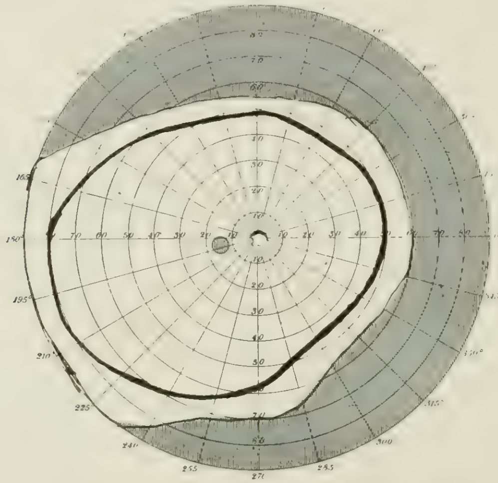


Fig. 29.
Showing Concentric Contraction, of Only Moderate Degree, in the Left Eye with Optic Atrophy.

(A) *Concentric contraction* (see fig. 29) concerns the peripheral area of the field, which is the expression of that retinal zone least active in defining form and color, and whose visual acuity is less than that possessed by the central zone field.

It is the area first to suffer with diminished illumination. Concentric contraction is often associated with changes about the blind spot of Mariotte, and the point of fixation. Sometimes the contraction is not equally concentric, but assumes at some part a sector-like enlargement extending into the intermediate, or even as far as the central zone.

Pure concentric contraction of the field due to organic disease does exist, however, and presents, together with normal central visual

acuity, and a normal color-field, a rather rare class of cases. In such cases we must suppose a normal condition of the macular bundle and its adjacent fibres in the optic nerve.

Uhthoff (*Arch. f. Ophthal.*, XXXIII 257) describes such cases, and the miscroscopic findings showed interstitial involvement of the nerve sheath of the entire trunk of the optic nerve, compressing and causing atrophy of its outer portions, and with the central bundles normal, or almost so.

Concentric contraction of the visual field occurs quite frequently in hysteria and neurasthenia. Von Reuss notes, however, that the concentric contraction of hysteria is permanent until recovery, while in neurasthenia it is constantly changing, even during examination. Temporary uniform concentric contractions to the degree that the field approaches a circle is found to follow upon hysterical, hystero-epileptic, or epileptic attacks.

Permanent concentric contraction, it is to be noted, is usually a symptom indicating organic disease. For further study of such fields the reader is referred to a point farther along in this article. Such concentric contractions of the field, as described, may be of considerable extent and yet pass unnoticed by the patient when in one eye, and even when in both eyes, and cause him little inconvenience. However, in certain conditions, notably in pigmentary retinitis and in hysteria, the field contraction from the periphery may be so great that it is encroached upon near to the area of fixation. Attention has been called to the modification of the contracting field, in a given case, when it is measured with the point of fixation placed at different distances from the patient. Especially in hysteria Schmidt-Rimpler (*Deutsch. Med. Wochen.*, 1892, Nr. 24) thinks such contracting fields should be tested with the campimeter placed at varying distances, and, testing in this way, he found that as the distance between the patient and the screen was increased, the field increased, i. e., the contraction decreased.

Greeff (*Berlin. Klin. Wochen*, May 26, 1902, p. 496) entirely disagrees with this statement, and thinks the size of the field is the same, tested at any distance from the point of fixation. Such extreme involvements are spoken of as *tubular contractions* (Röhrenförmiges Gesichtsfeld.)

Under this heading the writer will describe certain changes in the field, which, while extending often into both central and intermediate zones of the field, start in the field periphery.

Von Reuss, in his excellent and classic work (*Das Gesichtsfeld bei functionellen Nervenleiden*), describes several forms of visual field anomalies, and the writer acknowledges his indebtedness for a free

use of these descriptions. These conditions mostly concern hysteria and neurasthenia, and will be dealt with to a fuller degree under such headings.

(a) The "shifting type" (Fig. 30) is a condition first recognized and described by Förster, at the Heidelberg Congress of 1877. These changes in the field were observed in patients affected with anesthesia of the retina. While we usually observe that the test object, when carried centripetally—that is from the temporal to the nasal side—is later perceived in the temporal and longer in the nasal side, than when we test centrifugally, in this the "shifting type" the reverse is found.

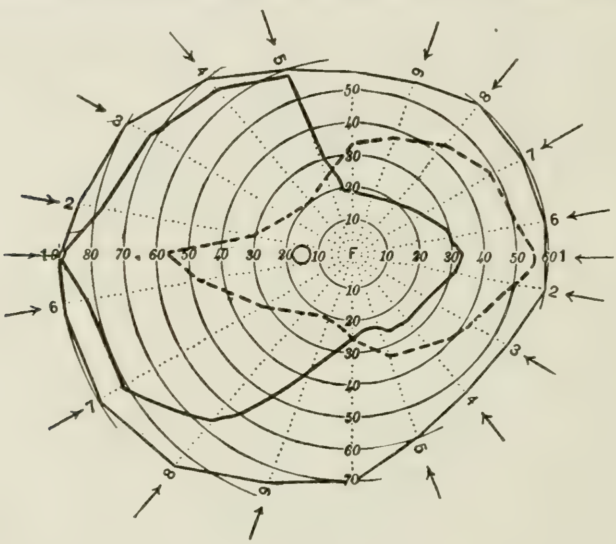


Fig. 30.
Shifting Type of the Visual Field. (Von Reuss.)

For example, it is to be observed in normal cases as we bring a test object along the 180° meridian *toward* the fixation point, the mark indicating its appearance will be nearer the field center, than the mark indicating its disappearance if the test object is carried along the same meridian *away from* the fixation point. Further, in the first case, had we carried the object along the same 180° meridian out of the nasal field, it would have disappeared at a point farther from the field center than the point marking the entrance of the object from without the nasal field.

This Förster found to be so in cases to which he applied the name anesthesia retinæ. The case illustrated was that of a girl sixteen years

of age with a vision of 20/100 in each eye and normal ophthalmoscopic findings.

(c) Unstable concentric limitation is a field which undergoes constant change during the examination. These three types are so closely allied, and concern retinal conditions almost entirely, that their difference is of no practical importance in diagnosis.

(b) The ''exhaustion type'' (Fig. 31) (Willbrand and Sänger, *Ueber Sehstörungen bei functionellen Nervenleiden*, Leipzig, Vogel, 1892, p. 10). This is a field obtained by passing an object from the temporal to the nasal, and from the nasal to the temporal, rapidly in succes-

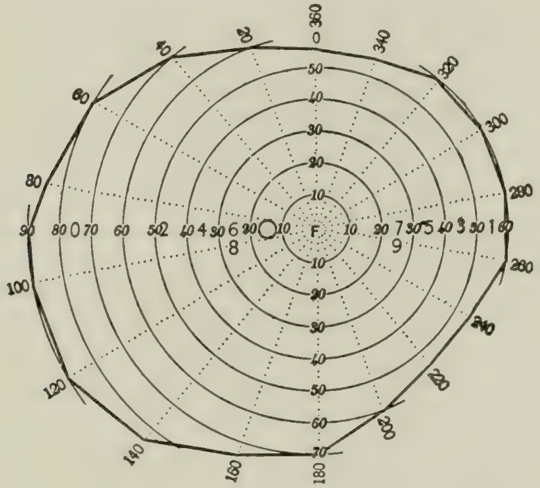


Fig. 31.
Wilbrand's ''Exhaustion Type'' of Field.

sion. The object is carried across the entire width of the perimeter, and these backward and forward excursions are continued as long as the field diminishes. Some authors classify this type with Förster's ''shifting type,'' but von Reuss holds this untenable since in Förster's and Wilbrand's method the only thing in common in the tests is the movement of the test object.

(d) The ''fatigue spiral type'' (Fig. 32) in which gradually diminishing concentric contraction may be traced as the coil of a watch spring (Uhrfeder) getting smaller and smaller as it unwinds toward the center of the field.

When von Reuss first reported a case with such a field in 1907 he considered it largely in the nature of a curiosity. Since that date cases giving such fields have been found not to be infrequent. Usually

in making our tests the test object is carried from outward toward the fixation point beginning at the first meridian—that is the meridian marked 0—and this is repeated at intervals of 15° on each succeeding meridian until the last, the 345° meridian, has been tested. These points are connected, and give us a perfect outline of the field, as is well understood, where we are dealing with the normal field. If one repeats this test the marks denoting the first appearance of the test object in the field will coincide or differ little with those in the second test. With the "exhaustion-spiral" type of field, however, this is not so, for here the marks denoting the first appearance, in each meridian,

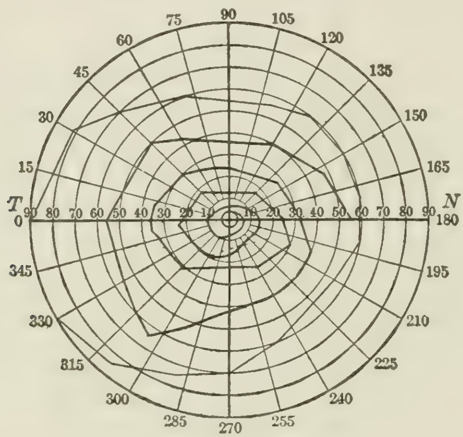


Fig. 32.
The "Fatigue Spiral Type" of Visual Field. (Von Reuss.)

in each different test, gradually approach the center. When one connects these points the so-called spiral is obtained.

It must be understood, of course, that the field is not of a spiral form, but simply that the retinal exhaustion manifests itself in a gradual concentric contraction under test, and that the deliminating points of these various tests, when connected, give the unusual contour. Such spiral fields are also obtained for red, green and blue, as well as for white.

(e) The "recuperative extension type" is found after obtaining a restricted field in a given case of retinal neurasthenia or exhaustion. It is sometimes possible, after a pause, to obtain a larger field more nearly approaching the normal limits. The amount of this recuperation and extension of the field naturally depends upon the degree of the exhaustion, also somewhat on the length of the recuperation period permitted.

These variations in the field-form mostly relate to neurasthenia, and later will be discussed under that heading, but, in addition to these, a field described by Wilbrand and Koenig may here be alluded to, viz., "the oscillating field."

The field known as the "oscillating field," is one in which the test object disappears, and reappears several times, on the same meridian. Similar oscillations may occur in testing the color fields. This phenomenon probably arises from rapid changes in the sensitiveness of the retina. By reference to the figure it will be noted that if the points at which objects disappear are all connected, and the like be done

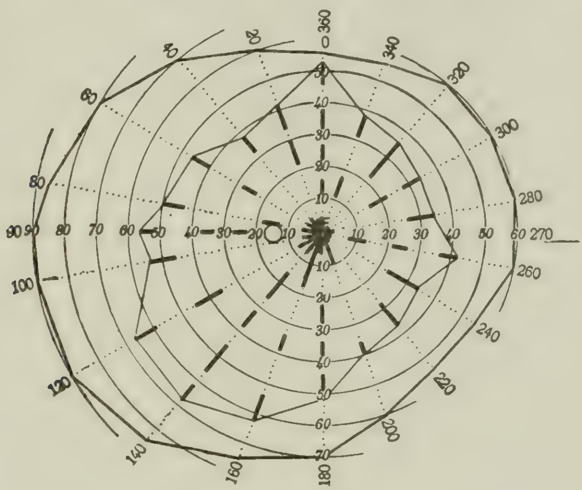


Fig. 33.
The Oscillating Visual Field. (Wilbrand.)

where they again reappear, we have, as pointed out by Wilbrand, a series of annular scotomata.

This may be (according to von Reuss) double ring scotoma, fragmentary scotoma, and may be associated with central scotomas, as well as with the so-called scintillating scotoma (Flimmer scotoma). As an index of their neurasthenic character, it may be stated that such scotomas due to this "oscillating field" are more permanent in contrast to such changes associated with hysteria.

(B) *Sectorial defects.* Since we may, properly, interpret a sectorial defect as any involvement of the field comprehended between two of its radii and its enclosed arc, all forms of defects—be they quadrant-shaped, a hemisphere (hemianopsia), or even greater areas —may properly be included under this heading, when such defects.

beginning at the periphery, infringe upon the field. These are not always regular in their contour as regards the two enclosed radii, are commonly bi-lateral, and are, as a rule, due to retrobulbar lesions.

(1) *Quadrant anopsias.* In this (see Fig. 34) the defect is so exactly comprehended between the horizontal nasal radius and inferior vertical radius up to the fixation point as to be almost quite diagrammatic.

Sectorial defect in one eye only, indicates a lesion in the nerve of that side, and, of course, anterior to the chiasm. Bilateral sectorial

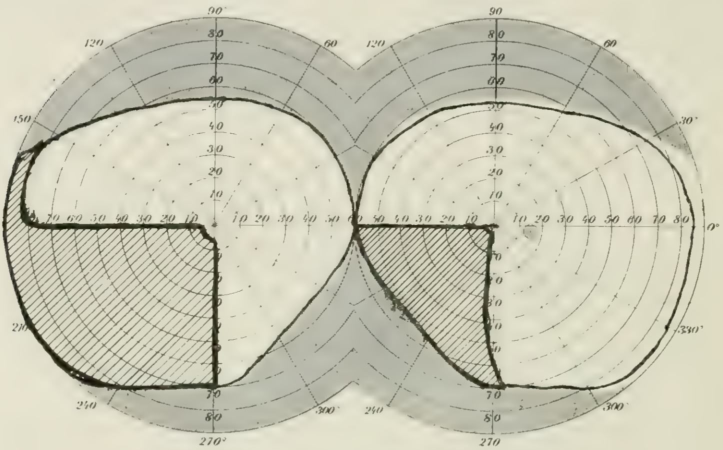


Fig. 34.
Showing Left Homonymous Quadrant Anopsia.

defects indicate a lesion in the chiasm, in the tractus, or even more posterior.

In quadrant anopsias the defect may be complete, that is, extending exactly to the horizontal meridian. In other cases there may be a band-like interval of vision, preserved between the defect and the horizontal meridian. These fields are interesting, and, to quote Spiller, "They seem to show that the upper part of the retina is represented in the upper part of the external geniculate body, and the upper lip of the calcarine fissure; that the lower part of the retina is represented in the lower part of the external geniculate body, and in the lower lip of the calcarine fissure; and that the horizontal zone of the retina midway between the upper and lower portions is represented in the base of the calcarine fissure." From this it follows that the fibres from the different portions of the retina in the optic nerve and optic tract must preserve their relative position.

Cases of quadrant anopsias have been reported by Beevor and Col-

lier (*Brain*, 1904), and Hunn and others. The former reported a case of blindness of the left upper quadrants of both fields, the fixation points in both being included. The necropsy showed that the only part of the cortex of the mesial surface of the occipital lobe escaping destruction was the upper two-thirds of the cuneus, and the anterior and ventral portions of the fusiform gyrus. This indicates that the upper two-thirds of the cuneus is the visual center for the lower quadrants.

Under quadrant hemianopsia, Weyman reports (see Harris, *Brain*, Vol. XX, 1897, p. 308) a case in which the lower quadrant in one eye on one side and the upper quadrant in the other eye on the other side were blind. See, also, **Military surgery of the eye,** p. 7803, Vol. X of this *Encyclopedia.*

(2) *Hemianopsia,* the term meaning *obscuration* of one-half of the visual field, is often used synonymously with the term hemianopia, which implies *complete loss* in the perception of one-half of the field.

The term hemiablepsia has also been applied to this condition. Since we wish frequently to refer to cases in which the loss is only relative, the term hemianopsia seems to be the one most desirable. This, then, is a contraction of the field, usually bilateral, in which the half of the field to one side of the vertical meridian, passing or not passing through the fixation point, is lost. It is often to be observed clinically that there remains in such fields, about the fixation point, a small area of retained fixation.

This latter phenomenon, of a retained visual area in the blind half about the fixation point, can be explained by the theory of the double representation of the macula in the cortex. In some cases the dividing line is direct and uninterrupted, passing through the fixation point, as noted elsewhere herein.

Wilbrand has, by a large series of observations upon accurately charted fields, compared with the pathological findings, evolved the theory of the fixed relation of each part of the retina, with its nerve fibres in the optic nerve and tractus, with its distinctly related center in the higher visual areas in the cortex about the calcarine fissure. He thinks that each and every part of the macula is represented in the right, as well as in the left, cortical areas. In cases where the dividing line of hemianopsia passes through the point of fixation, he believes double representation does not exist. For further light upon this subject the reader is referred to Wilbrand's work, as well as to Spiller's excellent article in Posey and Spiller's "*The Eye and Nervous System,*" to both of which the writer acknowledges his indebtedness.

When the line of demarcation passes through the fixation point we

speak of the hemianopsia as *total,* but in practice we include within total hemianopsia those cases, as well, in which the small central area about the fixation point is retained.

We may have "double hemianopsia" in which the entire fields are lost, with the possible retention of vision around the area of fixation.

Very often the field defect passes beyond the quadrant form into an almost hemianopic form, but yet far to one side of the median line of the field. Again in one quadrant the field may pass over the median line into the other side of the field, while in the other quadrant the blind line recedes from the median line. For a study of the myriad forms that fields in hemianopsia may assume the reader may consult the work of Wilbrand "*Hemianopischen Gesichtsfelde-Formen,* Wiesbaden, 1890."

Within a hemianopic field may occur a large, or small, area of vision, and we may find scotomas upon the other side of the field.

By a *relative* hemianopsia we mean a partial impairment of the visual recognition of the involved area. This relative hemianopsia may take several forms, for example there may be a diminished power to perceive color, form, or luminosity, as compared with the unimpaired field. In complete, absolute hemianopsia the field for white disappears, as well as that for color.

In the condition—a rare one—known as hemiachromatopsia, the white is either entirely unaffected or appears as gray, while the fields for color disappear. Wilbrand claims in explanation of this that the color centers are distinct and separate from the centers for form. Others disagree with Wilbrand, notably Ole Bull and Otto Dahnn, as well as Holden.

Holden (*Arch. of Ophthal.,* Vol. 24, p. 447) states his views as follows: "A slight interference in conduction of any of the fibres of the visual tract leads to an inability to recognize green, or even red, or to distinguish slight differences in luminous intensity. A more marked disturbance in conduction leads to inability to recognize blue, or to distinguish quite marked differences in luminous intensity. A greater interference with conduction prevents the distinguishment of white from black, and with complete interference with conduction even perception of light is lost.

"Thus the recognition of color fields, with a light sense, and the assumption of involvement of a particular cortical center in case of hemiachromatopsia is not only unnecessary, but is palpably erroneous."

De Schweinitz, (*Diseases of the Eye,* p. 559) thinks that the condi-

tion is caused by a cortical lesion simply one less in degree than that causing an absolute hemianopsia.

(3) *Form varieties of hemianopsia.* We may divide these into *horizontal,* in which the deliminating line approaches, or coincides, with a horizontal meridian; or *vertical* (most common) in which this line is vertical, or nearly so.

(a) Horizontal (or altitudinal) hemianopsia may exist as a field defect resting above the horizontal meridian, (*superior horizontal hemianopsia*), or as defects below this meridian, (*inferior horizontal hemianopsia*).

Such conditions may arise from pressure from above or from below upon the optic fibres in the optic nerves, or optic tracts. It is possible in a lesion of the chiasm to have a superior horizontal hemianopsia in one eye, and an inferior horizontal hemianopsia in the other eye.

(b) Vertical hemianopsia. (1) Homonymous hemianopsia, the commonest form, exists where corresponding halves of the two fields are defective, as right homonymous hemianopsia when both right fields fail, and as left homonymous hemianopsia, when both left fields fail.

The opposite field halves in these cases may be normal or suffer concentric contraction or may have involvements of their field centers (scotomas).

(2) Heteronymous hemianopsia is comparatively rare and is the term applied to the binasal, or the bitemporal, loss of the field; binasal, in which both nasal fields are affected, is rare. Unilateral nasal hemianopsia has been reported; bitemporal, or involvement of both temporal fields, exists. (See section "The field of vision in intra-cranial disease" in this article.)

(4) *The position of the line of separation in hemianopsia.* (a) In certain cases this coincides with the vertical meridian and cuts the point of fixation; (b) in other cases it passes beyond the fixation point, to the advantage of the seeing halves of the visual fields; (c) and in still another class it falls short of the point of fixation, the blind area encroaching upon the seeing halves of the fields.

Typical homonymous hemianopsia is always absolute, and the dividing line coincides with the vertical meridian and bisects the fixation point. When, as in the second class of cases, there is exclusion of the fixation point from the blind area, the dividing line lies in the vertical meridian until within 6° to 10° both above and below the fixation point, when it takes a curved direction about it. In some cases this demarking line lies from 5° to 10° removed from the vertical meridian along its entire course, and toward the blind side, thus adding a strip to the seeing half. It may also be situated to the under side of the

line of separation. In such cases the portion of the field lying beyond the vertical meridian extends into the territory of the optic tract supplying the other hemisphere, a condition in the field which we know as "*the overshot portion of field of vision.*" (Fig. 48.) The line of separation may pass through the point of fixation in such a way that, above, a wedge-shaped extension of the good field may exist between the line of separation and the vertical meridian, and, below, there is a corresponding wedge of blind area. The generally accepted view is that while the line of demarcation passes through the point of fixation, it more commonly evades it through adding it to the seeing half.

The explanation of this *phenomena of macular exclusion* in hemianopsia, has not been finally given, there being on this point no general agreement. The principal theories proposed to explain it have been: (1) The theory of Wilbrand, Henschen and Gowers that the macular center in each hemisphere innervates the whole of the maculæ, and the left brain also supplies both right and left.

This is known as the theory of "double representation of the macula." (2) The theory of Wernicke, Förster and Schweigger, diametrically opposite to that of Wilbrand, implies single macular representation, i. e., that, like the rest of the retina, each half of the macula is supplied by that side of the brain which supplies the retinal half in which this macular half lies. To explain cases of macular exclusion the advocates of this theory state that the abundant arterial anastomosis at the macula enables it to retain its function.

As pointed out by Swanzy both these theories are inadequate, since, by the first a tract, or chiasmal, lesion would always spare the fixation point, and, by the second, such lesions would always cause the dividing line to pass through it.

(3) Von Monokow states that there is no cortical center for the macula, and thinks the basal ganglia play an important rôle.

(4) Schmidt-Rimpler thinks that the variation in the position of the line of demarcation in hemianopsia is due to variation in the *distribution* of the retinal fibres in the tract.

(5) Hirschberg explains exclusion of the macula by an extension of the retinal fibres to the opposite side of the retina.

(6) Roenne (*Klin. Monatsbl f. Augenheil.,* Sept., 1911) thinks that when hemianopsia is peripherally complete, the macular fibres being more acute in function than the peripheral would still functionate enough to give the appearance of macular exclusion.

(7) Finally, there are those who hold the, no longer tenable, opinion that macular exclusion is not found in fact, but is the result of imperfect fixation in field taking.

Patients are much annoyed by hemianopsia, especially in right hemianopsia, since we read from left to right and the dark field constantly precedes the image sought after by the macula. In order to locate the exact position of the line of separation, test objects not exceeding 2 mm. square should be used.

The dividing line may be found exactly vertical, it may be oblique, or may extend around the periphery of the seeing half for a short distance above or below. These irregularities may be due to irregularity in the decussation of the optic nerve fibres. In cortical hemianopsia the vertical line is usually sharply cut, avoiding, however, the fixation point.

Excepting bitemporal hemianopsia this symptom has little focalizing value without the assistance of concomitant signs, since its commonest form, homonymous hemianopsia, may result from a lesion anywhere along the course of the optic nerve fibres posterior to the chiasm. Typical bitemporal hemianopsia is caused by a chiasmal lesion, such as aneurysm, bony tumor, arterial disease, and especially by disease of the pituitary body. (See in this article "The visual field in intracranial disease.")

Unilateral hemianopsia arises either from intra-ocular disease, or involvement of one optic nerve.

(C) *Scotomas.* All defects in the visual field, which do not extend to the periphery, are properly designated scotomas, that is, they are insular-like spaces of defective vision, lying within the field, and surrounded by a more or less normal field.

While the most frequent defect of the field is concentric contraction, yet insular areas of impairment are of great diagnostic importance, and must be carefully tested for..

(1) *Classification of scotomas.* (a) *As regards the patient's consciousness of the defect,* we recognize, a *positive scotoma,* when the patient is conscious of a blind area in his field, that is, when he actually perceives an absolutely dark, or clouded area, projected into space; and a *negative scotoma* as one of which the patient is usually not conscious, and which, while not projected as a totally dark area in space, projects itself as an area in which external objects are not perceived by the patient. In the latter case the defect is not discovered until the field is taken. Fuchs states that negative scotoma (the patient usually not recognizing) may become positive (the patient recognizing), in that the affected retinal areas insensitive to luminous stimulation can be recognized and projected as dark areas into space. It would seem here, however, that we had in final analysis nothing more than a positive scotoma to deal with.

In positive scotoma the symptom is usually due to peripheral lesions, as choroidal or chorio-retinal areas of disease, or congenital defects. While in the relative scotoma the symptom areas usually are due to lesions posterior to the bulbus. If the positive scotoma is in the media it is often movable and designated a *motile scotoma.*

(b) *As regards the degree of the scotoma,* we speak of absolute and relative. An *absolute* scotoma is one in which all perception of light is wanting. A *relative* scotoma is one in which the light-sense is subnormal, and the perception of color defective, usually for red and green. Such scotomas are known as color scotomas.

(c) *As regards situation,* we speak of *central* scotomas, when they lie within the central zone of the field, and include the point of fixation; *peripheral* scotoma, when situated in the peripheral zone of the field; *pericentral* scotoma, the point of fixation being at, or about, the center of the defect; *paracentral* scotoma, such that abut the point of fixation, it being near, or at the edge of the scotoma.

(d) *As regards the form, ring* scotoma, *annular* scotoma, a defect about, but excluding, the fixation point. We find *double ring* scotoma, and *multiple ring* scotoma. The latter may manifest organic disease, or may be found in the so-called oscillating field of Wilbrand, but are not true scotomas.

According as to whether one or more interruptions occur in a ring scotoma, we then speak of *incomplete ring scotoma, or fragmentary ring scotoma.*

It may be stated in regard to ring scotomas, found in the intermediate zone of the retina, between the 15° and 45° on the chart, that they correspond to the area in the retina supplied by the terminal branches of the short ciliary arteries, and arise from disease of these vessels.

We speak of scotomas as *round, oval, egg-shaped, irregular, eliptical* according as they approach, or assume these forms.

Scotomas are spoken of as *unilateral* where one eye alone is involved, or *bilateral* when affecting both eyes; symmetrical when corresponding areas in each eye are involved.

(e) *The "cribriform field,"* or *visus reticulatus,* is the term to fields containing a number of small insular defects of large or small degree, scattered throughout the field. These are usually found in the intermediary zone, and often extensive peripheral sectional defects are associated. Such fields are commonly found with grave cases of disseminated choroiditis.

(f) *Changes involving the blind spot.* Enlargement of the blind spot, or involvement in the central toxic scotoma is to be found.

"Spindle-shaped enlargement of the blind spot" is found in certain cases of optic neuritis, and will be discussed later in this division of this article.

(2) *Scotoma scintillans* (Flimmerskotom). This is an ocular manifestation of one of the so-called explosive neuroses, and, if monocular, probably due to local, and if binocular, to cortical disturbance of circulation. It is not uncommonly preceded by a visual aura in the form of indistinct and blurred outlines, scintillating lines, and zigzag flashes of light and colors. In extreme cases there may be associated hallucinations. This is followed by headache, often hemicranic in type. The scotoma may take on an homonymous character, sometimes being a small, at other times a large, area in the homonymous fields. The area is irregular, often with the convexity above. It may assume the outlines of a fortification and for this reason Airey, who himself was a sufferer, gave the name *teichopsia.* The duration is usually less than half an hour and fades away centrifugally. That the disturbance is cortical admits of little doubt, and in this connection it is interesting to observe that Kuns found phosphenes following light pressure made during an attack were referred to a different plane than that on which the scotomas were projected. A somewhat similar symptom to scotomas scintillans occurs as an aura in epilepsy and appears as an intense erythropsia.

Some authors consider sector-like defects, as well as hemianopsias, under the heading of scotomas, but for clarity and to avoid confusion, such areas are considered separately under the sub-headings of quadrant anopsias and hemianopsias.

(3) *Brief summary regarding scotomas.* According as to whether the central, intermediate or peripheral fields are involved, the patient marks in a very varying degree affection of his sense of sight. Isolated and circumscribed areas in the peripheral zone may pass unnoticed, and even marked concentric contraction in one eye especially, or even in both, may cause no serious inconvenience. In the intermediate area scotomas are more quickly noticed, especially if symmetrical, and may give rise to the so-called "telescopic vision," such as patients with retinitis pigmentosa complain of. Central involvement of the field is one the most suddenly forced upon the patient's attention, and is the field defect causing the patient deficiency in vision.

The nomenclature of scotoma is not a little confusing since the same scotoma may properly be indicated by several different names. For example, in toxic amblyopia, we may have a scotoma that is central, relative and often negative. A negative scotoma—one not usually perceivable by the patient—may become positive. An absolute scotoma

may be either positive or negative, according to the position in the field that it occupies, and as to whether it is, or is not, projected as a blind area before the vision of the patient.

Whatever the form of the scotoma it may be either absolute or relative, positive or negative. An absolute scotoma permits of no further subdivisions except so far as its form and situation are concerned.

We may have an oval, central and absolute scotoma, an annular peripheral, and absolute scotoma. An absolute scotoma may be positive or negative, but of course it cannot be relative. A negative scotoma may be absolute when perception of light is entirely lost over the area, or may be only relative when there is diminished form-sense, or loss of certain colors. In relative scotoma the fields seem normal until color objects are used.

(4) *The nomenclature of color changes occuring in the visual field.* As we may have contraction in the fields for form so we may find a peripheral insensibility of the retina to color showing itself as a concentric color narrowing. These narrowings may occur in the physiological order, or may exist in connection with color inversion, or color interlacing, or both. We may have scotoma areas for color as we have for form, and may find that so far as position and form are concerned the same nomenclature is applicable.

Total loss of the color-sense in the visual fields is rare, and when this form of color impairment is present the patient may recognize different degrees of brightness in the test objects, where the normal eye perceives each color at its true value.

Hemiachromatopsia is the inability to recognize color in one-half of the field, but where the loss of power to perceive color is confined to the peripheral, intermediate, and part of the central zone, leaving the region of the macula with normal color perception, we designate the condition central achromatopsia.

By *dyschromatopsia* we understand that there exists simply a difficulty in distinguishing colors.

Parachromatopsia is the incorrect perception of colors.

These conditions must be distinguished from *color amnesia,* or color aphasia, which is an affection in which the patient, while recognizing the true value of the color is unable to name the color recognized.

C. K. Mills proposes the term aleucopsia for the loss of the light-sense in the half fields. He also proposes for the loss of the sense of form the name *amorphopsia,* and when this is confined to half-fields the term *hemiamorphopsia* is used.

Hyperchromatopsia is a true enlargement of the color fields.

Just as we have concentric contraction, sector-like defects, and scotomas in the field for form, we may have corresponding defects for colors. These, however, will be dealt with under a special heading describing the different field defects occuring in disease.

By *color interlacing* we understand the phenomena which manifests itself by a running of one color line over the boundary and into its adjoining color field. This color lacing may, sometimes, be very complicated. It is observed especially in brain tumor as well as in some other conditions.

Color inversion is the term used to designate mis-placement of the color lines. The red field being larger than the blue, the green larger than the red, or the red even larger than the white.

THE FIELD OF VISION IN VARIOUS DISEASES OF THE EYEBALL AND OPTIC NERVE.

For convenience of study the field changes brought about through diseases of the eyeball itself will be considered in the order in which they involve the globe, from the cornea anteriorly, to the optic nerve posteriorly.

External affections of the eye. Slight *ptosis of the lid*, due to trouble with the third nerve, or to redundancy of tissue, may curtail the field somewhat in its upper part, as may also *symblepharon* of either the upper or lower lids, or even smaller adhesions due to trauma.

Corneal scars may affect the field, as may pterygia, but the measurement of such areas is of little interest and no practical value, and also exceedingly difficult, owing to the imperfect fixation of the eye involved.

Blurring of the field in one eye frequently passes unnoticed by the patient until his attention is drawn to it, owing to the overlapping retinal areas concerned with the field of binocular vision, since the uninvolved eye presents a clear image of the object which is blurred in the affected eye.

Congenital anomalies. Medullated nerve fibres. In an eye affected with medullated nerve fibres the field may show an irregular enlargement of the blind spot of Mariotte. This, however, is not always possible to discover where the presence of medullated nerve fibres has been revealed by the ophthalmoscope. This is probably because the fibres are not opaque.

Retinal and choroidal colobomata. These defects, in a measure, correspond to the retinal and choroidal changes which cause them, and as revealed by the ophthalmoscope, but it is to be remembered that the correspondence is by no means always an accurate one, and

for the reason that the portions of the retina in contact with the edge of the coloboma and choroid may not be totally impaired. It is to be noted, as pointed out by Lindsay Johnson (*Arch. f. Augenheil.*, XXI), that the contour of the retinal coloboma alone gives the contour of the field defect, that is, we are to understand that the field measurement of the choroidal coloboma would be greater, in such cases, than the retinal coloboma, and is a relative one instead of being absolute, as would be the case if the retinal defect exactly corresponded to the choroidal. Complete chorio-retinal-coloboma gives, of course, absolute scotoma, and, in form, corresponds quite closely to the form of the field defect. Colobomata of the retinal tunic can be measured only by perimetric tests, but here it is to be noted that they may be exceptionally well marked out upon a Bjerrum chart, or curtain, also by other methods, described elsewhere in this article. It is not sufficient, in outlining a retinal coloboma, if we are to define it accurately on the chart, that we use a white object only, since here we may be dealing with a relative defect, due to congenital choroidal disease, with participation of the corresponding retina.

Lindsay Johnson has devised an electric lamp giving parallel rays, which may be used as a test object in the sliding clip of the perimeter. With this intense light stimulation the defective retinal area may be more surely and more accurately mapped out. Colobomata on one side of the retina are projected on the opposite side of the field of vision, colobomata below the papilla appearing in the upper field, and *vice versa*. They may be peri-papillary, or be demonstrated as true macular colobomata in which case—as well as in extra-papillary colobomatas—due (Lindsay Johnson) to atrophy of congenital nævi of the choroid.

Wilbrand states that it is his experience that the extent of the coloboma, as shown by the ophthalmoscope, corresponds, in but slight measure, to the field charting of the perimeter.

Typical coloboma of the retina and choroid is due to defective closure of the fetal—so-called chorcidal—cleft. The condition is often bilateral and associated with coloboma of the iris and micro-ophthalmia. These patches are usually oval, or comet-shaped, with the rounding apex toward the disc. In typical cases the lower part of the retina and choroid are involved, giving, as stated, a field defect in its upper hemisphere.

Coloboma of the optic nerve entrance is, according to G. C. Crampton, (*Trans. Amer. Ophthal. Soc.*, Vol. §III, part 2, 1913) one of the rarest congenital anomalies of the eyeball. Coats and von Hippel believe that this should be called "coloboma of the nerve," rather than

"coloboma of the optic nerve entrance." Of coloboma of this nature, unassociated with similar defects of the adjacent choroid, Vossius (*Klin. Monat. f. Aug.*, Vol. XXIII, 1885) found only three cases in 12,000 patients. Parsons states that the shape is generally round, or a vertical oval, and in size may be twice, or twenty times, the disc diameter. Vision is sometimes normal, and again in other cases entirely lost. Crampton states that it is usual to find one eye normal, or nearly so, and the other blind, as was the case in both patients reported by him. Beard states the condition is usually binocular and shows the left eye in one of Crampton's cases in which there is inter-

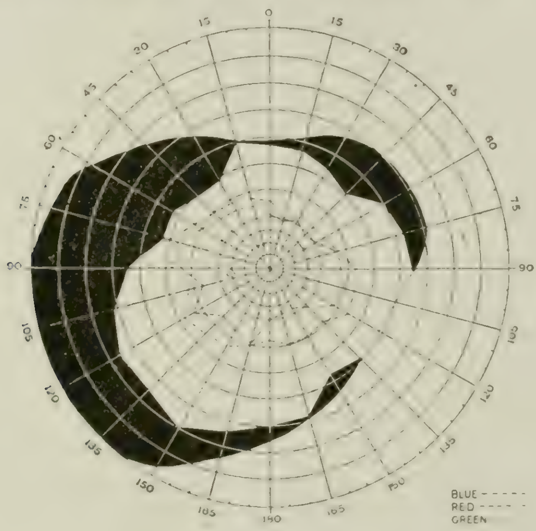


Fig. 35.
Showing the Visual Fields in Binocular Coloboma. (Crampton.)

rupted concentric contraction with greatest failure in the temporal field with noted diminution in the color fields.

Congenital conus. Congenital conus is stated by authors as showing itself as an enlargement of the blind spot. Wollenberg states that this is common among the mentally diseased, and Manz further states that the position of such enlargements of the blind spot is usually upwards, and that they sometimes extend laterally as far as the point of fixation.

Albinism. The writer has not himself attempted, nor has he found in literature an attempt, to study the changes in the visual field of albinos and in varying degrees of illumination. In this condition we find always marked defect in visual acuity, often associated with nystagmus, high myopia, strabismus and lens malformation. In the

normal eye some light passes through the iris and some even through the sclera. In this anomaly the visual confusion in all parts of the fields must always be great owing to the excessive passage of light through the iris.

Glaucoma. The writer believes that study of changes in the visual field which occur in glaucoma affords, perhaps, the most fascinating portion of all in the various field manifestations of disease in the visual apparatus.

The earlier writers, up to the time of Bjerrum, considered concentric contraction of the field, which was especially marked in its nasal central quadrant, as the classic symptom of the glaucoma field. Probably MacKenzie was the first to call attention to the sign.

That the earliest manifestations of this disease is not in the peripheral, but in the central, part of the field, is now well recognized. We will first consider these peripheral changes, and later, the changes in the central field, as called to the attention of the profession by Bjerrum.

There is no absolutely pathognomonic manner in which the peripheral field is invaded, although we find in the beginning that the nasal portion is involved more than are other portions. These peripheral restrictions will be observed to take one of several forms. (a) The most common, that of partial or complete loss of the nasal field, or sectorial loss of one of its quadrants. (b) Concentric contraction of the entire field, except a small normal area, often in the temporal side. (c) Oval contraction of the field. (d) Loss of the entire field, except a small normal area often on the temporal side. (e) Scotomas of any usually recognized shape. (f) Finally, by peculiar horn-like invasion from the blind nasal field below or above the fixation point curving toward and involving the blind spot near the horizontal meridian. (Bjerrum's symptom.)

Unlike the field of optic atrophy, the color restriction of the glaucoma field usually progresses *pari passu*, with the restriction for form, but this rule is not without exceptions. The earliest indication of glaucoma is to be noted in the central zone of the field, in the region about the point of fixation and blind spot, but the progress of the contraction peripherally is a more important index of the rate of progress of the disease. Wherever the restriction occurs it is, as a rule, continuous, that is, we do not usually find scotomas of the intermediate and peripheral zones, but if such do occur, it may generally be demonstrated that the parts peripheral to the scotoma have much diminished function.

The preponderance of the nasal field invasion appears to be more

common in chronic than in acute cases of glaucoma (Berry), rarely occurring in which the temporal field alone is involved.

From examination of one hundred cases in which excavation (glaucomatous) existed, Bunge made the following observations: defect in nasal portion alone, 27 cases; predominating in nasal portion—44; field assuming shape of peri-papillary scotoma—4 cases; entire loss of field, including center, except small temporal portion—9 cases. A central, or para-central scotoma, with or without slight nasal restriction—4 cases; upward restriction only, 2 cases; concentric contraction—6 cases; preponderance of defect in temporal field—4 cases.

This data of Bunge is very instructive, and shows the preponderance of nasal field loss, the rarity of temporal field involvement, as well as the comparative rarity of scotoma in the two outer zones. This latter remark does not apply to such changes as occur early about the fixation point, and which are known today as Bjerrum's symptom. Long-standing cases of glaucoma, with exceedingly deep excavations of the nerve, may be found in which both central visual acuity and the normal field are present. The writer himself has observed, and charted, two such cases over periods of seven or eight years. Schmidt-Rimpler describes a case of glaucoma with deep cupping and without field changes extending over twelve years. This indicates a commonly observed clinical fact that there is not always a correspondence in the depth of the cupping, with the changes in central vision and the visual field changes.

In the prodromal attacks of glaucoma central vision, as well as vision in the outer field zones, is diminished, and after a severe attack the field is generally permanently affected.

In such cases this decrease in the field is usually concentric, and predominates nasally and may be due to the intraocular pressure causing an anemic condition in the retinal periphery (Wilbrand).

Stellwag (*Diseases of the Eye*) long ago pointed out, and it has since been frequently observed by other writers, that when concentric contraction has progressed extensively, "the further reduction of the field is then very exceptionally concentric; as a rule there is contraction to a small slit, whose direction is almost always diagonal, and in which more or less color perceptions are possible."

The oval areas of preserved vision occurring in the process of concentric contraction of the field are but phases in the disease, intermediate between the typical early peripheral contraction, and the slit-like areas of vision, observed very late in the disease.

Noyes (*Diseases of the Eye*, p. 509) says that if the patient be made to face the window a limitation of the field not otherwise mani-

fested may be developed by the glare, and cites a case that, tested in this way, showed central scotoma which was not detected when the back of the patient was toward the light.

It is to be remembered that in the acute attacks of glaucoma the indistinctness, or haziness, of vision, as well as the "halo" phenomena, are not so much due to changes in the percipient parts of the eye, as to the interruptions of light caused by opacity of the dioptric media. The perception of actual cloudiness, and especially of actual darkness, in the field, are, on the contrary, due to actual disturbance in the retina

Fig. 36.
Showing Contraction of the Field to a Slit-like Form in Glaucoma with Remaining Good Central Acuity of Vision.

and optic nerve. We may find a high degree of central visual acuity retained, with a markedly diminished field. (See Fig. 36.)

Schnabel (*Centralblat f. Augenh.*, 1887) found fifteen such cases among 180 eyes afflicted with primary glaucoma.

While, in simple glaucoma, central vision, as a rule, decreases gradually, yet it may be retained to a high degree and attended with marked diminution of the field.

It is to be noted that in the slit-like fields observed in advanced cases of simple glaucoma, there may still be present the recognition of color.

In advanced contraction of the field in glaucoma there may be difficulty in deciding between this condition and optic atrophy with deep cupping of the nerve head, but here the retention of color perception will lend its weight to the probability of glaucoma.

The remarks so far made are based in large measure upon our knowledge of the glaucoma field prior to the years 1889-92. At about this time Prof. Bjerrum first drew the attention of ophthalmologists to certain forms of defects that had as yet escaped notice, and which were only discovered by methods of testing more exact and accurate than heretofore used. Since that time Bjerrum, his assistant Rönne, Fleischer and others, notably Sinclair, of Edinburgh, have added refinements in the taking of such fields. The details of this method of examination are described elsewhere in this article (see "Methods of examination"), but it is probably well-known that Bjerrum's system consists, briefly speaking, in the employment of very small test objects, and the placing of the test screen at a greater distance, usually at 2 m. This method is not employed for the taking of the peripheral field, since the minute test object employed is not visible by the normal eye beyond a short distance from the point of fixation. Bjerrum, by his method, found in a series of cases small defective areas extending from the blind spot, forming an arc above or below the fixation point, and ending at the nasal side of the fixation point about the horizontal meridian, thus according to Rönne (*Klin. Monat. f. Augenheil.*, Jan. 1909), corresponding to an involvement of the para-macular bundles of nerve fibres.

In other cases, Rönne states, a narrow defective area is found, passing upward or downward, either above or below, around the fixation point, somewhat farther away from it than in the first class of cases mentioned; reaching out to the peripheral portion of the field, toward its nasal side merging into the blind area long since recognized as commonly existing in the field of glaucoma cases.

With care the test object may be carried along the narrow defect, from the blind nasal field to the blind spot, without its being visible to the patient. "The fibres thus seen to be chiefly affected are those which emerge from the edges of the disc above and below to subserve the nasal and para-central portion of the field, while those travelling inwards and presiding over the temporal half of the field, and also the macular fibres, remain longest unaffected."

As the disease progresses there is to be found, often, a blind area at the retained portion of the field. Again the field may be divided into two portions, a small central area reaching out to the blind spot, and a larger temporal field; these two being completely separated by the blind spot.

In the progress of the disease the one or the other of these two areas may be abolished, leaving, as the case may be, a small central field, or a larger temporal field.

Bjerrum while admitting that these characteristic features may not be elicited at the time of the test, thinks, nevertheless, that in every case, early or late, these features will at one time or another be shown. He further believes that the peripheral amblyopia is due to compression of the optic nerve fibres at the cup margin and not to interference in vascular supply by pressure on peripheral vessels.

These signs are not absolutely pathognomonic, since other trouble arises from pressure at the lamina cribrosa, for example, neuritis. Priestley Smith, however, goes so far as to state that in the absence of these signs of Bjerrum, the case is probably not one of glaucoma.

In forty-five charts of cases of glaucoma Rönne calls attention to the fact that each exhibits, in some form or another, certain of these described changes, and calls further attention to the sudden break in the nasal field.

"This curious fault consists in a sudden change in the boundary line of the field, at the inner side from almost vertical to horizontal, along the horizontal meridian; after so running for a varying distance it again resumes its quasi vertical direction. As is well known, it is just along, or close to, the horizontal meridian, that the fibres which run upwards from the disc meet again those which run first in a downward course from it, forming a sort of horizontal raphé. On the disc these two sets of fibres are separated by those which preside over the macula, just exactly those which resist most successfully the injurious process in glaucoma, and therefore this occurrence rather helps to strengthen Bjerrum's theory as to the situation of the lesion which produces the peculiar scotomata in glaucoma."

A form of this nasal peculiarity may possibly exist in the, occasionally to be found, horizontal hemianopsia, for, if the field be taken carefully, it is often found that on the nasal side there is a greater failure below than above the horizontal meridian.

Rönne (*Klin. Monat. f. Aug.*, Jan. 1909) says that one in making the tests should not adhere to meridional excursions of the test object, but should use circular movements with the fixation point as the center. It is only by so testing that the nasal step is discoverable.

Indicating the superiority of the Bjerrum method over ordinary perimetry Rönne says that in 87 cases in which ordinary perimetry betrayed no sign, the Bjerrum method disclosed a distinct lesion in 51, and is especially valuable in the diagnosis between glaucoma simplex and primary atrophy of the optic nerve.

Fleischer confirms the results of Bjerrum and Rönne and, with them, agrees that a normal blind spot excludes glaucoma. As these changes

in the field precede any possible ophthalmoscopic detection of fundus changes the great value of the method is apparent.

J. Kuschel agrees that the changes in the glaucoma field about the blind spot are due to direct disturbance of the nerve fibres at the position of the excavation of the papilla, and that disturbances of circulation in the retina and the direct injury to the retina by compression are secondary factors in the causation of the variation of the typical glaucoma field. This author, as well as Rönne, points to the similarity of visual field changes in early glaucoma and papillitis.

The fields for colors usually diminish more rapidly than the field for white, but this is not constant. for it is to be remembered that the

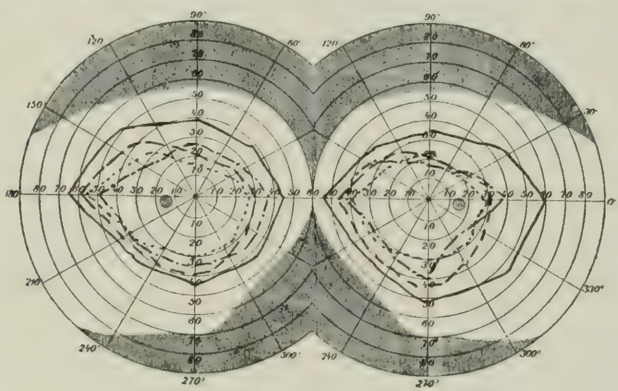


Fig. 37.
Showing the Field in Hereditary Glaucoma. (Calhoun.)

form fields may be much reduced, and the color fields still retain their normal limits.

Gruening (*Trans. Am. Ophthal. Soc.*, 1902) states that great reduction in the color fields indicates a nonfavorable prognosis.

In simple glaucoma with concentric contraction of the field, recurrent transient failure of vision is sometimes observed, the patient analyzing with poor central acuity and contracted field that gradually clears up to normal central acuity and normal field limits. The cornea in such cases is sometimes steamy, which may indicate the cause as here rather than in the retina.

Calhoun (*Trans. Am. Med. Ass'n*, 1914) writes at length upon the subject of hereditary glaucoma. The earliest cases were mentioned by Benedict in 1842, and von Graefe in 1869 mentioned the importance of heredity in glaucoma. Regarding the field of vision in these cases Calhoun says: "While the visual fields were not characteristic, there uniformly existed a great confusion for colors." (See Fig. 37.)

Regarding the influence of miotics in preserving the visual field in glaucoma, Posey, (*Trans. Am. Med. Association*, 1914) reports a large series of cases, in addition to 65 he had already reported in 1908, showing that by the proper use of miotics, the extent of the visual field is wonderfully preserved. He believes in the superiority of the drug treatment, and says that it is much more beneficial in simple chronic glaucoma than the removal of a portion of the iris. Posey lays special stress upon administering the drug in the proper way. He begins with exceedingly small doses, in order to avoid spasm of the ciliary muscle, rapidly increases the dose until the pupil is strongly contracted, and asserts that this degree of contraction should be maintained as long as the patient lives. The visual fields in many of his cases under this treatment remained absolutely normal for long periods of time. One presented a normal field after 21 years; 5 after 18 years; 1 after 16 years; one after 14 years; 2 after 12 years; 1 after 10 years; 2 after 8 years; and one after 7 years.

Effect of operation upon the glaucoma field. It is generally well accepted in practice that satisfactory improvement in vision is to be expected only in acute glaucoma, and with an early operation; to a less degree in sub-acute ("chronic inflammatory") and that improvement in the field of vision following operation in simple glaucoma does not often result. Many of the cases in the latter class display after operation poorer central vision and greater reduction of the field than before operation.

Noyes (*Diseases of the Eye*) states that the reduction in vision is in a measure due to the enlargement of the pupil and to astigmatism following the operation, but that in some cases the reduction is the result of mischief from the operation, and he further says: "If limitation of the field approaches close to the macula, central vision is pretty sure to be lost by the operation."

Retina. (1) *Retinal anemia*—usually an expression of constitutional disturbance—does not commonly affect the field. With extreme narrowing of the retinal vessels from vasomotor spasm there may be complete or partial blindness. When partial these attacks very often take the form of a hemianopsia. The writer has not unfrequently observed such cases and usually finds associated pupillary changes, as dilation, often unilateral. The attacks are transient and are not infrequently followed by severe headache, thus presenting a picture more or less typical of so-called ophthalmic migraine.

The extreme type of anemia is to be found in embolism of the central, or a branch of the central, artery. In the first case we may have loss of the field, in the latter happening there are often sectorial losses

depending upon the branch of the artery affected, for example the superior temporal artery occluded we find defect in the inferior nasal field, when the inferior nasal artery is affected the defect appears in the superior temporal field.

Priestley Smith states that if the blindness appears from above it denotes that the obstruction is retinal, but if the approach of the blindness is lateral its cause arises in the cortical visual areas.

The writer has found cases with field changes of a transitory nature due to cortical area disturbance associated with visual distortion. In two such cases the transient hemianopsia was associated with marked disturbance of cerebration, such as visual hallucinations, phantasmagoria, processions, etc., before the mind of the patient. The two cases, which were in the same family, both recovered.

I have not observed that general high arterial pressure affects the field.

Complete ischemia of the retina and loss of the field may occur in toxic diseases of certain drugs. (See **Toxic amblyopia.**)

Complete obstruction of the central artery usually means entire blotting out of the field, yet if a cilio-retinal artery be present, central vision may be retained in the form of a narrow oval extending from the point of fixation toward the blind spot.

C. F. Clarke thinks this symptom not sufficient to prove that this area is retained by a vessel supplying the papillo-macular region. Owing to the anastomoses of the ciliary and retinal vessels about the papilla (circle of Haller and Zinn) we may have some slight retention of the field on its temporal side.

Hancock (*Royal London Ophthal. Hospital Reports*, XVII, part III), apart from the retention of the central area in the field, found eccentric areas which were functionally active. In 88 per cent of these cases the retention areas were to the temporal side of the field, which he ascribes to an anastomosis of the retina with the choroidal capillaries, which usually only extend far enough forward on the nasal side to connect with the choroidal vessels.

Rarer are the changes in the field which show themselves as a central, or even para-central scotoma. Levy (*Trans. Ophthal. Soc. U. K.*, Vol. XXIX) and Miller (Graefe's *Arch. f. Ophthal.*, Bd. LXXXII) have reported such cases in which the obstruction was in the cilio-retinal artery, and not in the central.

After complete loss of vision from embolus central vision may be completely regained. Snell (*Oph. Record*, 1911) reports a number of such cases.

(2) *Simple retinitis* has nothing distinctive in its field expression,

but we find besides a cloudiness of central vision associated with micropsias, macropsias and metamorphopsias, and concentric contraction of the field.

It is to be remembered, however, that with retinitis we may have some papillitis, and here, as Rönne has pointed out, we may find field changes that simulate in some degree those found in early glaucoma, i. e., the Bjerrum symptom.

(3) *Syphilitic retinitis.* Here the condition has generally been accepted as a chorio-retinitis, or in fact a choroiditis alone, but Nagel has pointed out that it is not alone the choroid but the retina, as well, that is involved. Here we find lowered central vision often associated with night-blindness. Irregular and concentric field contraction and ring scotoma are often present.

(4) *Albuminuric retinitis* may produce changes, but not distinctive ones, in the field all depending upon the location and extent of the lesions.

Gerhart and Simon state that certain changes in the color perception found in this disease are distinctive. The former says that the field may contain blue-blind areas, that violet-blindness is to be found not uncommonly in albuminuric retinitis. In the albuminuria of pregnancy sudden loss of the field, partial or complete, is sometimes to be seen. This phenomena is probably due to toxic influences acting upon the cortical visual areas. These symptoms, in degree, extend from a cloudiness to total amaurosis, and may be hemianopic in character.

Central punctate retinitis may, according to de Schweinitz, produce a relative or positive scotoma while the peripheral field remains normal.

(5) *Retinitis pigmentosa.* In this disease the changes in the visual field have been recognized as distinctive. While, in good illumination, central vision may remain almost normal, or quite so, it is found that the other zones of the field do not fare so fortunately.

The peripheral field at the onset of the disease may, in good light, appear normal, but in diminished light this changes to marked peripheral contraction. In advanced cases the contraction of the field is so extensive that only "barrel-like" or "telescopic" vision is preserved, a condition that also occurs in certain neuroses affecting the field. Even in some very advanced cases in which this telescopic vision is within the narrowest limits, the patient, within this small area of retained vision, may have good central vision, reading by fixing one single word at a time. The retinal periphery is often, in the early stages, free from this pigmentation, while the intermediate zone, in

part, is involved, thus giving a diseased area. Between the little affected central and peripheral zones of the retina we find annular scotomas, which Hepburn states is the earliest manifestation of this disease. As the disease advances the outer zone is so far involved that the scotoma disappears in the blind field periphery, and central vision alone remains.

In these cases night-blindness is a classic symptom, the disease at its onset quickly affecting the light-sense. Many of these patients can get about very well in bright day-light, but upon the onset of twilight must be assisted.

Hepburn (*Trans. Ophthal. Soc. U. K.*, Vol. XXVIII and *Royal London Ophthal. Hospital Reports*, Vol. XVII), using a McHardy perimeter and 10 mm. test objects in good illumination, studied the visual fields in pigmentary degeneration of the retina. He found the main field features in primary degeneration of the retina (retinitis pigmentosa) to be the presence of ring scotoma between the 40° and 10° circles (practically the entire intermediate zone of the visual field), with a tendency to wider temporal extension. These scotomas varied much in shape and, not infrequently, showed within the defect insular areas of vision. In the beginning of the disease the scotoma is incomplete and may be absolute, or relative, or partly absolute or partly relative. Some cases revealed a double ring scotoma. His study of the fields lead him to believe that the temporal half of the retina loses its function entirely before the nasal half begins to degenerate. The degeneration in the nasal segment is more rapid downwards, and finally when the entire peripheral field has been destroyed the macular region is obliterated. Those cases already mentioned in which the central field first disappears, Hepburn regards as cases of chronic choroiditis which have assumed the appearance of retinitis pigmentosa.

Primary and secondary pigmentary cases are difficult, or impossible, to distinguish ophthalmoscopically, but Hepburn thinks that the visual fields of the two types may serve as a guide to their differentiation.

It is to be observed that there is not always to be found an intimate relationship between the degree of the retinal changes seen by the ophthalmoscope, and the extent of the field changes, although with very great retinal pigmentation the fundus changes are usually accompanied by marked field defects.

Koellner (*Zeitschrift. f. Augenh.*, Aug. 1906), by using a brilliant electric lamp for a test object, found that peripheral areas of the fields of greater or lesser degree were functionally active at very late stages of pigmentary degeneration.

(6) In so-called *retinitis punctata albescens*, Mooren, Hirschberger and Fuchs report central scotomas, relative or absolute, with unaffected peripheral fields. Fuchs called attention to the similarity of fields in this condition, and the fields of pigmentary retinitis, as well as to the similarity of these fields to the field found in that rare and peculiar disease called by Fuchs *atrophia gyrata chorioidæ at retinæ.*

In retinitis punctata albescens Fuchs and others found noticeable contraction of the fields taken by a feeble light, and little or no con-

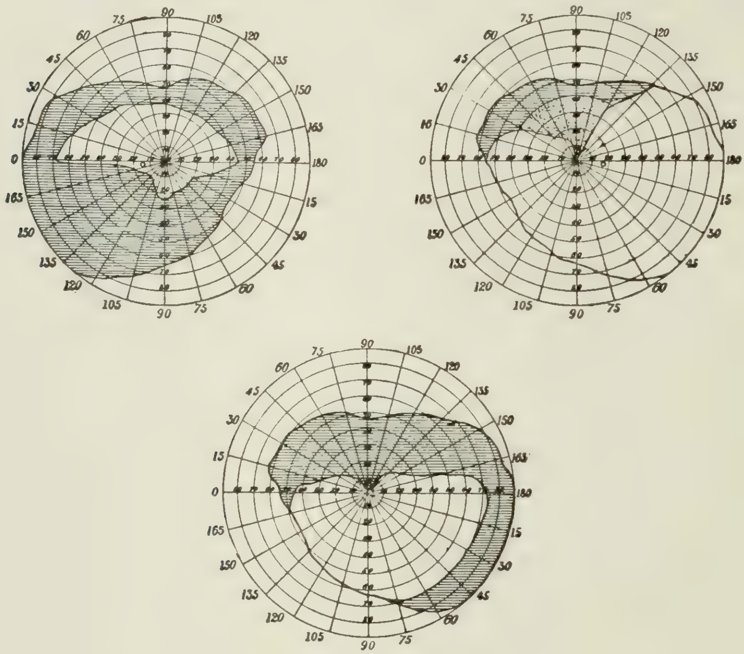


Fig. 38.
Showing Concentric Contraction as Well as Ring, or Annular, Scotoma in Pigmentary Degeneration of the Retina. (de Schweinitz.)

traction in such fields taken in strong light. This difference in fields when they are taken under feeble, or strong, illumination is said by Nettleship, Sinclair, and others to apply to cases of *hereditary congenital night-blindness*, without ophthalmoscopic findings.

(7) *Retinal detachment* from serous exudation usually appears below the horizontal meridian of the retina and shows itself, therefore, commonly in the upper field. The extent and position of the blind area in the field corresponds to the extent and position of the disease in the retina. (See Fig. 38.)

Very often the loss of the field comes on very suddenly, and generally

from above, the patient stating that it seems as though a curtain had been drawn before the eye.

A beginning retinal detachment may not be observed ophthalmoscopically, or even in testing for form (with white test object), but may be detected as a relative scotoma if we employ a blue test object. The patient complains of the distortion of images, (metamorphopsia.) The macular region may not be involved and good central vision be retained for some time, this, however is gradually lost. After almost complete field loss rest in bed may bring about some restoration of function that shows in a recuperation of the field periphery for form, but as the writer has personally observed recently in a case this improvement is usually disappointing in that the vision is again affected, and finally lost.

(8) *Retinal traumatism*, due to concussion, or to laceration, from penetrating foreign bodies, may give, when the test is made on a Bjerrum screen, or scotometer, various shaped scotomas, corresponding, of course, to the position and extent of the injured area.

Leber describes cases in which the blow upon the eye left no perceptible lesion, or ophthalmoscopic change, but in which considerable defects in the field were found as scotoma, or concentric contraction, and these defects often remained permanently. These cases Leber calls *traumatic anaethesia* of the retina.

A central scotoma may follow a blow upon the eye from a cork, in which the ophthalmoscope will show cloudiness and hemorrhage in the retina.

(9) *Photo-traumatism* of the retina. (Solar retinitis; electric retinitis). Positive central scotoma for white, and color, or for color only, may follow exposure of the eye to the sun's rays (for example, during an eclipse), to electric lights, or exposure from the brilliant light reflected from the snow. This may be absolute, or relative, and while usually disappearing, in some cases is permanent.

Valois (*La Clinique Ophth.* March 1904) found contraction (concentric) with temporal pallor of the disc due to exposure of the light of an arc lamp. The writer has observed a case in which relative central scotoma and peripheral contraction occurred in a dentist whose eyes had been exposed for some years to a brilliant light used in his work-shop.

Dor (*La Clinique Ophth.* March 1909) reports a case of sector-like defect following a severe electric shock, and Beauvois, Ferentinos, and Casali report contractions of the field for form and color, after exposure of the eye to the sun.

Photo-traumatism. Under this heading J. H. Claiborne reports a

very intersting case of persistent ring scotoma following repeated and prolonged gazing at a furnace fire. The case is of such interest that the writer feels justified in inserting it.

The patient, a mechanical engineer, had for nine months, while experimenting over various kinds of fuel, gazed for long periods of time at the fire through a round door. After six months he noticed a dark ring. Euphos glasses temporarily relieved the annoying symptom of a dark spot in his field of vision. The scotoma was in the left eye and central color perception for red and green was normal in both eyes. The form field was very little reduced. The scotoma was not absolute and after the end of 12 months had undergone no change. Claiborne thinks the lesion lies in the retina of the left eye. The optic nerves in both eyes were remarkably red, the veins enlarged, and in the right eye a pulsating vein; otherwise the fundi were normal.

Regarding photo-traumatism of the retina, Weidenberg (*Zeitschr. f. Augenh.*, Oct., Nov., Dec. 1913) exhaustively treats this subject. He tabulates 188 cases. It is shown that monocular injuries of this type predominate, the right eye being the one usually affected. In a series of 22 cases, 15 were affected in one eye, and 7 in both eyes. These cases were all due to gazing at an eclipse of the sun. The intensity of the injury depended upon the duration of the exposure, and on the protection of the eye. The symptoms were diminished vision and central scotoma appearing on the first or second day. This scotoma was usually positive, and in many cases of an oscillating type (flimmer-scotoma). The scotoma was usually central; it was seldom negative or relative and not often para-central. The peripheral field disturbances consisted in narrowing for white and red.

Choroid. In the fields associated with choroiditis the distinguishing feature is the patchy nature of the small scotomas throughout the field, they being of all shapes and sizes. These are scattered throughout the field and give rise to the so-called "cribriform field of vision," (*visus reticulatus*). (Fig. 39.) These small scotomas are usually found in the intermediate zone of the field, that is, between the 15° and 45° circles, and, exterior to this area, are often found larger, or even as vast, peripheral zonular defects.

These cribriform fields are often found in disseminated choroiditis where disease has involved the layer of rods and cones and caused atrophy of these structures. We find here extreme defects in the color fields, that for blue being often greatly contracted.

In chronic choroiditis the central field may entirely disappear, the fundus showing signs not unlike pigmentary retinitis.

Scotomas, in case of choroiditis, may remain stationary a long time, and with attendant concentric contraction of the field.

Changes in the transparency of the media due to exudation and formation of opacities may cloud the field, or give rise to large dark areas in the field, that move with the ocular excursions.

Disturbances of vision are in direct relation to the situation and extent of the lesions, if they are peripheral good central vision may exist, and cases of markedly diffused choroiditis may be found in which little or no change in central, or even peripheral, vision exists. Micropsia,

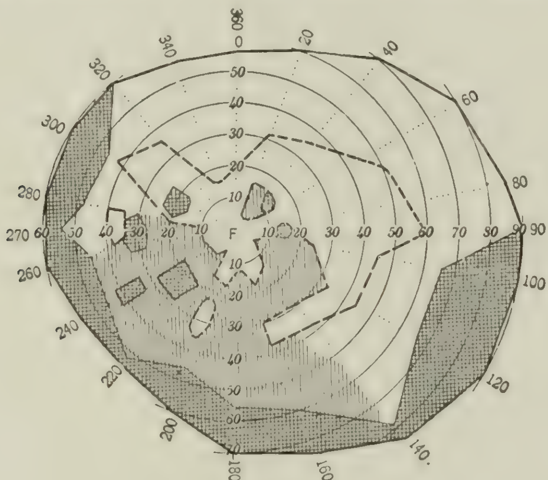


Fig. 39.
Cribriform Field of Vision. (Wilbrand.)

macropsia, or metamorphopsia may be present, due to disarrangement of the retinal elements lying over the diseased choroid.

In sclero-choroiditis posterior there is, at times, to be found an increase of the blind spot, indicating an atrophy of the rods and cones over and above the choroidal area involved. In these cases, and in hugh myopia, the consequent lowered choroidal nutrition may induce torpor retinæ, which may manifest itself by a greater degree of concentric contraction than commonly occurs in myopia. This may explain in certain myopic eyes the inability to obtain good vision even after accurate correction of existing errors of refraction.

Optic nerve. (1) *Simple papillitis.* It is a fact well observed that the changes in the visual field occurring in papillitis do not always bear a direct relationship to the degree of inflammation of the nerve head, insofar as the extent of these defects are concerned. Wilbrand

states, that as long as the choking of the disc is due to edema the conductivity of the nerve fibres remains but slightly affected; and that when the infiltration accompanying the hyperemia develops slowly, the field does not seem to be disturbed, since the nerve fibres may be pushed to one side and adjust themselves to their new position. He cites Becker's case, (Graefe-Saemisch *Handb. der gesamt. Augenh.*), in which the optic nerve process remained an entire year in a state of high pressure, yet normal vision was preserved. However this may be, we find, not infrequently, field changes very early in the disease. Rönne and others have pointed out that in the early stages of nerve head inflammation the central zone of the field shows changes very similar to those occurring in early glaucoma.

In inflammation of the nerve head the field of vision presents for consideration its periphery, which may at first be unaffected and later show irregular and concentric contraction; increase in size of the normal blind spot, which becomes correspondingly great in comparison with the amount of swelling; the formation of an abnormal blind spot or scotoma, due to involvement of the axial fibers, and sometimes to destruction of the ganglion cells; the absence of half of the visual field (hemianopsia), when the intracranial mischief—which may have been the cause of the neuritis or choked disk—is so situated as to produce this phenomenon; and, finally, defective color-perception, which may exist when there is no change in central vision and no limitation of the form-field. Cushing and Bordley have found reversal of the color lines, as it occurs in hysteria, in association with increased intracranial tension with or without choked disk, as well as blue-blind areas, which disappeared, after the restoration of intracranial tension to normal, by operation. Although reversal of the color lines in these circumstances undoubtedly is frequently demonstrable, it cannot, in the author's opinion, be regarded as a safe indication of the existence of increased intracranial tension.

Central vision may be entirely unaffected, hence good visual acuity does not exclude the necessity of ophthalmoscopic examination.

In a case reported by Knapp (*Trans. Am. Ophthal. Soc.,* 1870) the blind spot was greatly increased due to the swelling of the nerve head. Knapp was possibly the first to call attention to this condition.

Usually as the disease progresses there is increased concentric contraction, with sector-like invasions into the field, and some drawing in of the color lines of the color fields.

Accompanying the choked disk is frequently retinal edema, which may in itself diminsh central acuity and give an area of relative sco-

toma in the field, or which may amount to areas of cloudiness (partially positive).

(2) *"Spindle-shaped" enlargement* of the blind spot (see Fig. 41). Ramsay and Sutherland found a "spindle-shaped" enlargement of the blind spot associated with congestion of the nerve head in cases clearly those of sympathetic irritation. Ordinarily the vertical length of the blind spot has to its horizontal breadth the proportion of 6 to 4, with about 1-3 of this whole space above the horizontal line drawn through the point of fixation. In the five cases recorded by these writers the enlargement was altogether vertical, and there was no change in horizontal width. The tests were made on a Bjerrum screen. All five cases were those of papillitis due to sympathetic irritation, all the other eyes had suffered injury. In three of the cases the proportion of the vertical to the horizontal length of the blind spot was as 12 is to 4, in one as 10 is to 4, and in one as 18 is to 4. The authors, as a result of careful study of these five cases, think "It highly probable that under certain circumstances the spindle-shaped enlargement of the blind spot may furnish an important and valuable danger signal of the approach of sympathetic irritation, and that it seems highly probable, if not almost certain, that the spindly-like enlargement of the blind spot denotes active congestion of the optic disk, the shape being determined by increased size and turgescence in the superior and inferior branches of the retinal artery and vein." Since the above was printed, Dr. Arthur Sinclair's paper on "Bjerrum's Method on testing the Field of Vision" has been published in the *Transactions of the Ophthalmological Society* for 1905. In this paper Dr. Sinclair mentions, that "Irregular extensions of the amblyopic area usually occur at the upper and the lower margins, and correspond generally to the position of the large blood-vessels as they leave the disk. If, then, in a case of infected wound, or of degenerative changes in one eye its fellow began to give trouble, no matter how slight, and careful examination showed a congested disk with the characteristic enlargement of the blind spot, the sign would, in our opinion, go far to determine the question of the immediate enucleation of the exciter."

In four of the five cases a low degree of transitory myopia which disappeared upon removal of the injured eye afforded confirmation of the impending sympathetic inflammation.

(3) *"Leber's disease"* (also known as "hereditary optic neuritis" and "hereditary optic atrophy") is an affection of the papillo-macular bundle of neurons which manifests itself in the visual field by a central scotoma, and terminating in more or less partial atrophy, according to Cargill (*Ophthalmoscope,* Feb., 1912, Vol. X). It is usually bilateral,

occurs as a rule in males, is transmitted by affected females, and was first described by Leber (*Arch. für Ophthal.*, Bd. XVIII), when he reported 18 cases, occurring in five families. Later Habershon (*Trans. Ophth. So. U. K.*, Vol. VIII), and Hancock (*Royal London Hospital Reports*, Vol. XVII) made valuable contributions to the literature.

The typical clinical picture of this disease is described by Cargill thus: "A male between the ages of 17 and 30, and usually about 20, discovers one day suddenly that there is a mistiness before the objects

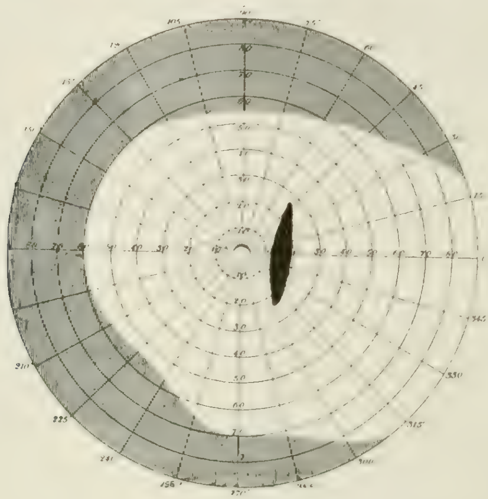


Fig. 41.
Spindle-shaped Enlargement of the Blind Spot.

which he is desirous of regarding directly and intently, while there is relative clearness on viewing them indirectly or looking to one side." This Cargill states is due to a central scotoma, either relative or absolute. The peripheral limits of this field are usually unrestricted. The field is better under moderate or feeble light than it is under strong light. These field changes increase rapidly during the next week or two until sight is reduced to the reading of large print or counting of fingers. The pupils react sluggishly to light, but react well to convergence. The ophthalmoscope shows clear media, and no fundus changes, other than a certain amount of hyperemia of the nasal half of the disk, with a moderately contrasting pallor, or ischemia, of the temporal half. Later the disk assumes an increased whiteness. In this very remarkable disease with its very interesting field changes the progress is peculiarly favorable as many of the cases recover gradually.

This recovery is slow, however, taking six to twelve months, and in other cases one or two years, and usually leaving the light-sense imperfect, even after visual acuity is regained. The scotoma may clear from the center, and for white and red, before it clears for green and blue, leaving a narrow ring scotoma for a time. Unlike ordinary retrobulbar retinitis the field defects are usually bilateral and the family history also offers some assistance in suspected cases.

Nettleship (*Trans. Ophthal. Soc. U. K.*, Vol. XXIX) suggests that some of the "astonishing cases of cure from long-standing blindness" may be explained by this class of cases.

Atrophy. The field changes in atrophy of the optic nerve will be considered in detail under the several diseases causing such defects, but for the purpose of preserving continuity in this division a brief general review of the visual field changes in atrophy will be given:

(1) Changes in central vision. At the onset of the disease, and before ophthalmoscopic changes, the writer has observed that patients complain of vague, almost indescribable, visual annoyances. This may be simply visual confusion, or actual blurring. Correction of refraction, as a rule, does not dissipate this complaint of the patient.

(2) Changes in the light sense. Many of these early cases show the light-difference increased, and little affection of the light-minimum. Investigation of the light sense is important. According to Samelsohn the light-perception in glaucoma is much lessened, while the light-difference power is relatively not greatly affected, but in optic atrophy the reverse is usually observed.

(3) Form changes in the field. Almost all, or any, form of modification of the normal fields may occur in atrophy, but the following are those commonly to be found: (a) Concentric contraction. (b) Concentric contraction with sectorial-shaped incursions. (c) Quadrant anopsias and hemianopsias. (d) Central, or in some cases peripheral, scotomas.

In concentric contraction there is little of localizing value, but in the hemianopsia and quadrant anopsia associated with other signs we may have information of diagnostic importance.

Kooy and de Kleijn of Utrecht (*Arch. f. Ophthal.*, Vol. 77, part iii) in referring to fields in optic atrophy state that while most fields are represented as continuous, that the campimeter will reveal in such fields functionating retinal regions. They think that these may be responsible for the slight annoyance experienced by patients with strongly contracted visual fields. These writers have found such islands present in eleven cases of optic nerve disease due to various causes, as brain tumor, multiple sclerosis, tabes and intestinal hemorrhage.

Regarding the relation of central visual acuteness to the defects of the visual field in diseases of the optic nerves, Wilbrand, together with Jacobsohn, formulates the following rules: 1. If central visual acuteness and the visual field are synchronously diminished, it is a sign that the disease has attacked the whole optic tract. 2. If central visual acuteness is diminished and the visual field is lessened by sector-shaped defects which seem to cut into the field from the periphery, it is a sign that, though the whole optic tract is affected, yet those parts related to the sector-shaped defects are more disturbed. 3. If central visual acuteness is markedly diminished, with a relatively free periphery in the visual field, a central scotoma, which may be relative or absolute, is to be suspected. From the fact that the central visual acuteness, in contrast to the peripheral visual acuteness, is not only absolutely but relatively better preserved, the authors believe that the conclusion may be drawn that the disturbance of function in optic atrophy shows a tendency to spread commonly in a centripetal direction.

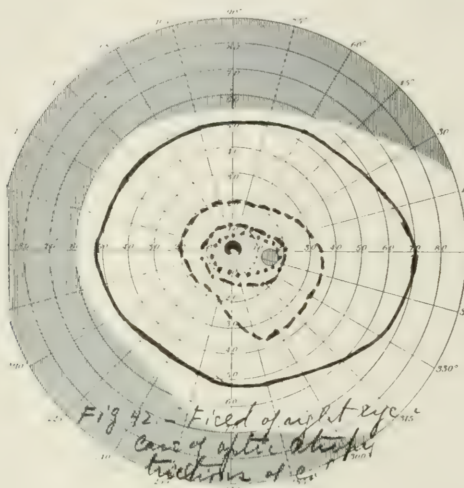


Fig. 42.
Field of Right Eye in Optic Atrophy.

(4) Color field changes. The color-fields are of importance and interest in optic atrophy. There is always to be found some defect in color vision, and changes in outlines of the color-fields. (Fig. 42.) The contraction, as a rule, affects first the green, then the red, then the blue field in the field periphery, and the color loss in the central field occurs in the same order. As we shall later see, this order may be reversed. Contraction of the color-field is greater than that of the form-field, generally speaking.

Retro-bulbar neuritis. (*Toxic amblyopia.*) While it is to be remembered that not all inflammations of the orbital portion of the optic nerve are axial, that is, involving the papillo-macular bundle of nerve fibres, and that sometimes the peripheral portions of the nerve, or the entire nerve, are involved, yet, in considering the effect of certain drugs as they manifest themselves in the visual field we think that there are many of them which seem to have some selective influence upon the central nerve bundles of the optic nerve, with resultant symptoms generally more or less distinctive.

Among the most important and frequent toxic substances liberated in the system are those from alcohol and tobacco. Uhthoff in his classic monograph (Graefe's *Arch.*, Bd. XXXII, 1886, and *ibidem*, Bd. XXXIII, 1887) out of 138 cases of toxic amblyopia from all causes, found that 64 out of this number arose from the abuse of alcohol. By far the greater number of visual field defects from the use of certain drugs are caused from alcohol and tobacco. J. J. Evans (*Ophthalmoscope*, December, 1911) says, "The character of the visual fields in toxic amblyopia is largely dependent on the nature of the lesion produced by the toxic agent; where the lesion is a retrobulbar axial neuritis, as is generally the case in poisoning by alcohol, tobacco, iodoform, carbon-bisulphid, etc., a central scotoma with full fields is the rule. On the other hand contraction of the peripheral field, with, or without, central scotoma is found when the lesion is one of primary or secondary optic atrophy, as in poisoning by lead, quinine, methyl-alcohol, filix mas, atoxal, etc."

This statement may serve as a working hypothesis but in the first class of cases defined by Evans it is not at all uncommon to find with the central field involvement some peripheral contraction, and in the second class of cases it is also to be observed that scotoma occurs without peripheral contraction. The writer, therefore, thinks it is practically impossible to very definitely ascribe particular field defects to a particular drug, as it is not uncommon to find changes in the field simulating tobacco and alcohol amblyopia from other drugs. Typical departures from the rule are found in certain cases due to any drug. It is important, however, to remember that toxic amblyopia and axial neuritis are not interchangeable terms, for we may have the peripheral portion only, the axial portion only, or all portions of the orbital part of the optic nerve, involved in affections of the visual field due to toxic agents. Where we have typical cases of so-called toxic amblyopia the character of the scotoma is usually distinctive and interesting. This scotoma is usually a red-green, blind area, ovoid in form, and affecting a certain length of the visual field usually extending from the blind

spot to the fixation point, and at times passing inwards nasally beyond the fixation point.

Usually the field for green is smaller than that for red, i. e., the area of green-blindness is greater than the area of red-blindness. The color contraction throughout the field is usually symmetrical in its approach toward the center, and in extreme cases, scotoma for blue and yellow exist, and again we may find cases of absolute scotoma. Except in those later to be spoken of, the peripheral field is not involved.

The scotoma may, at the onset of the disease, be very small and

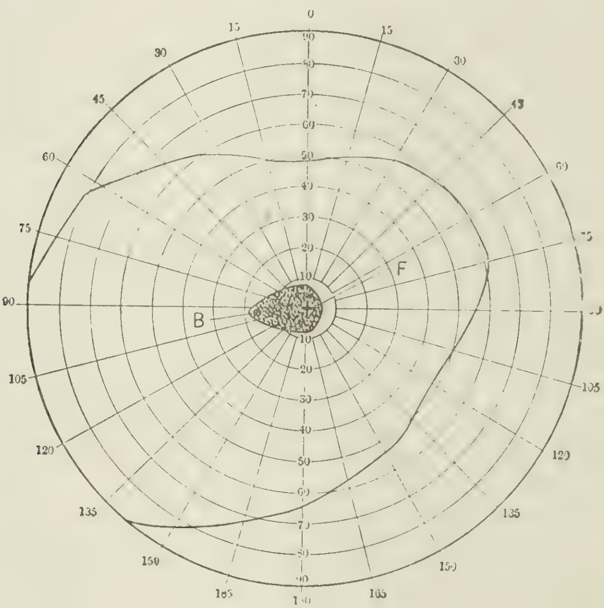


Fig. 43.
Papillo-Macular ("Egg Shaped") Scotoma: F, Fixing Spot; B, Physiologic Blind Spot.

exactly at the fixation point, and in testing these cases, if the scotoma is absolute, accuracy can only be obtained by using a macular selector on the unaffected eye since fixation being imperfect the eye may make slight lateral or vertical excursions affecting the charting of both the relative and absolute blind areas. (See Fig. 43.)

The oval, or egg-shaped, scotoma is said by Groenouw to result from the union of two scotomas, the one beginning at the fixation point, the other at the increased blind area about the blind spot. Here the processes may retrogress, the color-defects gradually disappearing, or it may progress, which is indicated by increase in the color-field defects

until the defect meets the limit of the red field. This phenomenon in the field we speak of as the breaking through of the scotoma (see Fig. 44). In severe cases blue and yellow scotomas are found.

Bjerrum states that within these color scotomas a small scotoma for white may be demonstrated if small test objects are employed. Usually the scotomas are bilateral but may be unilateral, when they are bilateral they are occasionally found asymmetrical.

In regard to the color scotoma Sachs states that the average size of this is outwards 18°, inwards 5°, upwards 7°, and downwards 6°. De Schweinitz has found practically the same results, excepting only that he finds inwards 3° instead of 5° as given by Sachs. This scotoma

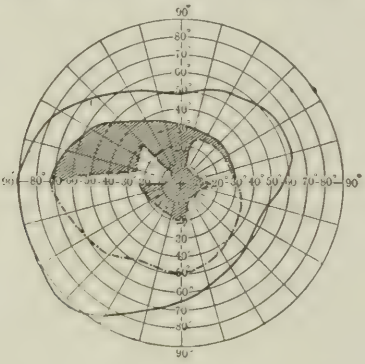


Fig. 44.
Visual Field, Showing So-called "Breaking Through of the Scotoma."

is egg-shaped in contour with its more pointed end toward the blind spot.

Uhthoff (*loc. cit*) gives as the classic symptoms for visual changes occuring in the field in tobacco amblyopia the following: Defective central vision, ($\frac{1}{3}$ to $\frac{1}{40}$ of normal), pallor of the temporal, or lower and outer quadrant of the disk, and a central relative scotoma, a red-green blind area. Scotomas for blue, as well as absolute scotomas, are less frequently observed. (See Fig. 45.)

The onset of the central fogginess, or blurring, may follow within a few hours after the induction of the toxic cause, or several days, possibly eight or more, may intervene in the acute cases; while in the cases of tobacco-alcohol amblyopia, as well as some other drugs, the onset may be so gradual that it, at first, is scarcely appreciated by the patient, and may manifest itself as a mere transitory blurring of central vision that may not again be noticeable for a shorter, or longer, period. The writer has had in his experience a few cases where after

the taking of large quantities of wood alcohol a sudden blindness (absolute complete amaurosis) occurred, with immobility of the pupils, and with thread-like contraction of the arteries and retinal pallor. Two of these cases never regained vision, and showed white atrophy of the optic nerve-heads. It is not unlikely that many of these cases with central field changes are, as Holden and Birch-Hirschfeld have pointed out, due to nutritive changes in the entire nerve.

Especially in tobacco-alcohol amblyopia full peripheral fields are the rule, but Holman (*Mitt. aus der Augenklinik in Jurjew*, Bd. II, 1904) has found contraction of the peripheral fields for both white and color.

Color defects may occur in the peripheral field and according to

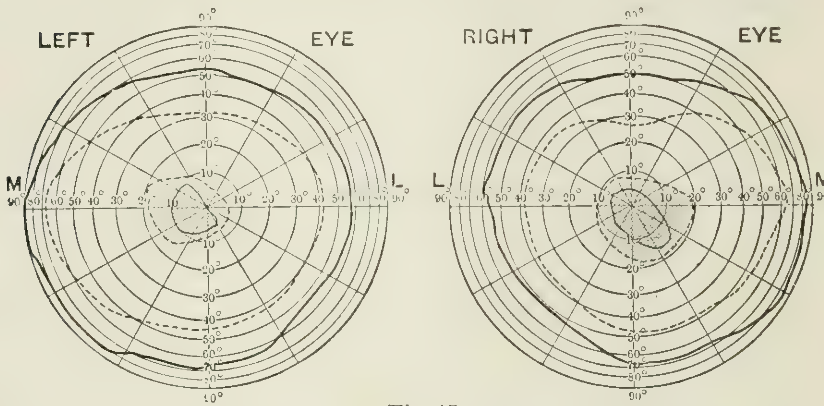


Fig. 45.
Alcohol-amblyopia. Small Absolute Defect in Scotoma for Blue. (Uhthoff.)

Demicheri (*Arch. d. Ophthal.* Oct. 1897) are usually sector-shaped, and are always relative. In rare cases, contraction of the color-fields is present without central scotoma.

Rönne (*Arch. f. Ophthal.*, Vol. 77 part i) in an anatomic examination of the visual tracts in 38 cases of alcoholism found that the degeneration of the ganglion cell layer in the retina, in cases of toxic amblyopia, were proportionate to the extent, and intensity, of the central color scotoma.

Harman (*Lancet*, Vol. VII 1904) states that if the fields are taken in diminished light concentric contraction may be found in most cases of tobacco amblyopia. Bär (*Klin. Monat. f. Augenheil.*, Oct., 1905) found that the scotoma occurring in optic amblyopia was, when typical, horizontally oval, but he, like Groenouw, found that there were often two small disconnected scotomas.

The green field is first to suffer and usually the last to recover.

As to the part played by tobacco, alcohol and other drugs, in the

bringing about of visual field changes due to retro-bulbar neuritis, there has been much discussion. This is especially true as regards alcohol and tobacco amblyopia. Concerning this matter the statistics of Adler (*Wien Med. Wochen.*, 1898) are interesting. Among 100 patients he found alcohol was the greatest factor in 86 per cent, but states that nearly all the patients smoked more or less. In 12 per cent the patients smoked and did not drink. In his hospital practice there were 19 per cent. of nicotine amblyopia and 81 per cent. of alcohol amblyopia, but he admits that this testimony was not entirely trustworthy.

Uhthoff's examination of 327 cases of intoxication amblyopia showed

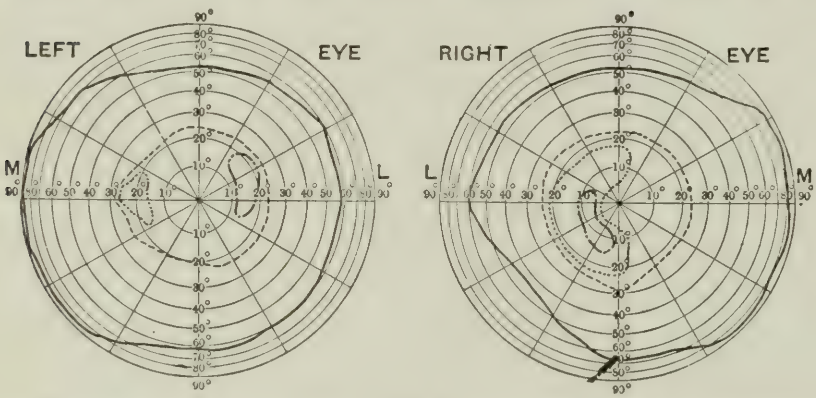


Fig. 46.
Alcohol-amblyopia. Unusual Type, Showing Peripheral Color Field Contraction Without Central Scotoma. (Uhthoff.)

the existence of pure tobacco amblyopia in 41 cases. The remaining 286 he divides about equally as due to alcohol alone, and to the mixed influence of alcohol and tobacco.

M. L. Foster (*Trans. Am. Ophthal. Soc.*, 1913) reports a case of central scotoma in the left eye with central visual acuity of $^{20}/_{200}$, (wearing a correction of + 1.75 sph.) A central scotoma for red was present on the left side and the temporal side of each of the optic nerves was very white. The interest of this case lies in the fact that Foster believes he has encountered a case of pure tobacco amblyopia, and that alcohol as a cause is entirely eliminated. He presents evidence to sustain his case that would seem to be very satisfactory, probably almost incontestible. Foster says "A single case of this kind is enough, I think, to prove that tobacco *alone* is a competent cause of the lesions characteristic of tobacco amblyopia." It may be added that the patient recovered after total abstention from tobacco. An interesting

feature of the case was that in the left, the worse affected eye, at the end of eight months distinctness of vision was $^{20}/_{15}$ and in the lesser affected eye, the right eye, vision was $^{20}/_{10}$.

In the discussion relating to this case Gruening, of New York, stated he had never seen a case of pure tobacco amblyopia, and that in the central scotoma due to disease of the papillo-macular fibres he could always point to the influence of alcohol. Gruening quoted Van Millingen, of Constantinople, to the effect that among the Mohammedans, who smoke excessively but do not drink, there never was in his experience scotoma due to affection of the papillo-macular fibres. He further stated that this form of tobacco amblyopia is unknown among Cubans, who, it is well known, smoke much. This alleged immunity of Cubans and Spaniards from tobacco amblyopia has been disputed by Finlay (*Arch. Oph.*, Vol. XXX) who quotes many cases to establish his point that such immunity does not exist.

There have on the other hand been quoted well authenticated cases of tobacco amblyopia pure and simple, as in cases of women working in tobacco factories, reported by Theobald as well by de Schweinitz. It is interesting to note that the blindness of horses in Australia has been attributed to the eating of the wild tobacco plant, as reported by Barrett.

Nuel, in 1895, contended that the central toxic scotoma is not caused primarily by neuritis of the macular bundle, but by disease of the macula lutea causing degeneration of the ganglion cells, the optic nerve changes being secondary to the macular. This Uhthoff strongly disputes, stating that the primary effect of the drug is on the papillomacular bundle of the optic nerve, although he admits that secondary changes in the macula may exist.

While tobacco and alcohol are the most frequent causes of retrobulbar neuritis other drugs may cause inflammation of the orbital portion of the optic nerve which may be indicated in the visual field by changes more or less resembling these two agents.

A long list of drugs which may exert their toxic influence in this way may be given, but that which follows comprises the more common to be met with: viz., nitrate of silver, chlorate of potassium, mercury, arsenic, atoxyl, bisulphid of carbon, nitrobenzol, salicylic acid, oil of wintergreen, cannabis indica, coffee, tea, stramonium, male fern, iodoform, osmic acid, chloral, antipyrin and lead.

It is necessary, however, to speak somewhat more in detail of the visual field in cases of lead, quinin, methyl-alcohol and atoxyl.

De Schweinitz's investigations, as well as those of Holman, Drualt and Birch-Hirschfeld have shown that the first effects of the toxic in-

fluence of quinin is to lessen the blood supply of the retina and optic nerve; following this permanent optic nerve atrophy ensues.

Holman has demonstrated, and his findings have been confirmed by Drualt and Birch-Hirschfeld as well as other observers, that the amaurosis, or visual field changes, in quinin-poisoning, are due to a degeneration of the ganglion cells and nerve fibres of the retina, and that this is followed by an ascending degeneration of the optic nerve. After the ingestion of a large quantity of this drug the restoration of central vision may be complete. We have a concentric contraction of the visual fields, which may widen out but does not again reach its normal limits. Scotomas may appear in the visual field in such cases.

De Schweinitz (*Arch. of Ophthal.*, March, 1910) reports a case of quinin-blindness, with sudden onset and absolute character during its existence. There was gradual restoration of central vision with ultimate return of central color-sense. The fields following were elliptically contracted with the longest axis in the horizontal meridian. H. Knapp stated this to be the rule, although not an invariable one. Certain cases are reported where the preserved portions of the field are in the form of islands. These are rare, however.

In cases of quinin intoxication changes in the fundi do not always bear a direct relationship to the degree of change in the visual field. Not infrequently with extreme optic atrophy following quinin amaurosis almost normal vision may be found present and while generally attendant with defects in the form field as well as defects for blue and red the patient is able to orient fairly well.

Methyl-alcohol may cause complete blindness, as seen in the two cases already spoken of by the author. The amount of wood alcohol it is necessary to take to affect central vision, or other parts of the visual field, varies very greatly, and Casey Wood and Buller have indicated in their investigations that methyl-alcohol intoxication is an example of idiosyncrasy. A very few cases of restored vision are reported, and usually the blindness is so complete that the discussion of the visual field ceases to be of interest. If the dose is large, however, absolute central scotoma and contracted fields may be found.

The first case of methyl-alcohol amaurosis was probably reported by Viger in 1877. Many cases have been reported since. The amount of wood alcohol necessary to cause blindness varies greatly in the individual case. Blindness and atrophy have followed the ingestion of from two to five drams (Raub), ½ oz. (Burnett), while complete recovery without visual disturbance has been observed after the ingestion of half a pint or more.

In this connection it is interesting to note the visual field changes

which occur in the so-called Jamaica-ginger blindness. H. Woods has reported (*Ophthal. Rec.*, 1899, p. 55) six such cases. He ascribed the blindness to a neuritis of toxic origin due to Jamaica-ginger. Harland (*Ophthal. Rec.*, Feb. 1901) seems to have demonstrated satisfactorily that the toxic agent was not the ginger itself, but the methyl-alcohol with which it was adulterated, since the alcohol used in the manufacture was composed of 75 per cent methylic and ethylic-alcohol.

Blindness has followed the taking of bay rum and cologne spirits.

De Schweinitz (*Ophthalmic Record*, 1892) believes that there is not the slightest doubt that wood alcohol, like quinin, acts primarily upon

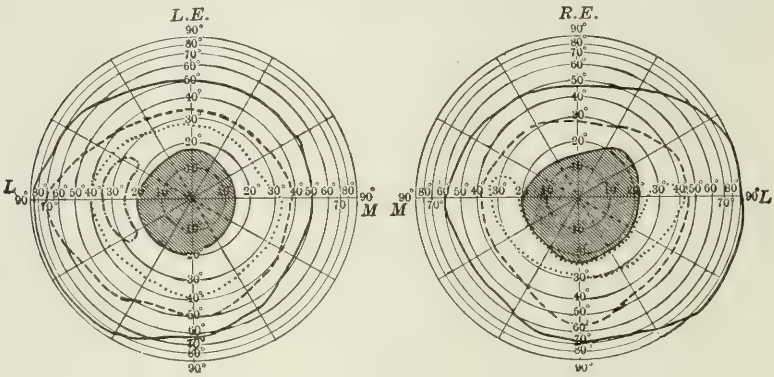


Fig. 47.
Showing Field in Lead Poisoning.

the ganglion nerve cells of the retina, and that the optic nerve changes are secondary.

In atoxyl poisoning the following symptoms have been reported: Reduction of the visual acuity from ½ to complete blindness, contraction of the visual field, especially to the nasal side, usually no central scotoma, but at times a central scotoma for colors, and at times color-vision.

As with alcohol and tobacco, so may lead-poisoning give rise to changes in the field. The eye symptons nearly always being preceded by the general symptoms of lead-poisoning. The disease presents typical central scotomas which may be attended by concentric contraction for form and colors. The scotomas sometimes assume the form of a hemianopsia. The ophthalmoscopic findings may vary from negative ones to marked organic changes as neuritis, atrophy, perivasculitis. In 64 cases analyzed by de Schweinitz, 13 showed neuritis, and 17 optic atrophy.

Hirschberg and Knies regard lead amaurosis as identical with uremic amaurosis. Westfal, Hertel, Elschnig and others report hemianopsia.

Bihler reports a partial left nasal, and partial right temporal hemianopsia in the same case, and with complete hemiachromatopsia. The usual symptom however, is central scotoma. The field changes occur infrequently, when the total number of cases are analyzed. Des Planches found only 12 cases out of 1217 of lead poisoning in which field changes occurred. This agrees with both de Schweinitz and Packard. The latter found no eye symptoms among 33 cases of lead poisoning. Uhthoff reports 204 cases of retro-bulbar neuritis among 30,000 patients, and out of these 204 cases 138 were toxic in origin, and among these only one was due to lead. The changes in the field may be transitory and due to the anesthetic effect on the nerve and retina, or they may be permanent and due to retro-bulbar neuritis, which may result in atrophy.

Lowe (*Archives of Ophthal.*, 1906) reports a case of total amaurosis after lead poisoning that in less than a month had normal F. V. and normal color fields. In these cases the amaurosis must be central and due to a toxic agent of some kind.

Transient amaurosis and disturbance of F. V. according to Lowe is possibly due to sudden ischemia of the eye. It has been shown that increased arterial tension precedes the subjective symptons of lead colic and this may be due, like the visual changes, to increased tension.

Jean Dalegowski says changes in the F. V. are due to edema of the nerve sheath which all observers admit to be sometimes present.

Ward A. Holden (*Trans. A. M. A., Section of Ophthalmology*, 1914) reports a case of toxemia occurring during pregnancy at about the seventh month. For five days she had had diplopia and vision had grown rapidly worse; besides a paralysis of the left external rectus, there was an absolute central scotoma in the field of each eye so extensive that vision was reduced to the recognition of movements of the hand, but these movements were visible in the entire periphery of each field. After the induction of labor vision became rapidly better, becoming for central vision $^{20}/_{20}$ in each eye, and with entire restoration in the fields. After her recovery she experienced much difficulty in seeing at night, and in each macular region of the retina was found abnormal pigmentation. Some four months after this the pigmentation had spread from the macular region to the periphery of each retina, vision still remained $^{20}/_{20}$ in each eye. One year later, after the onset of this condition, the eye remained with normal central vision and normal fields.

This disturbance of the visual field with pigmentary degeneration Weil and Wilhelm think due to retention of the blood of certain salts, causing hydropic disturbances, as edema and eclampsia with sudden

blindness and with the fundus changes; while they think the retention of nitrogenous substances causes albuminuric retinitis.

Holden states "The complete transitory blindness with normal fundi is a fairly frequent symptom of eclampsia. In the rare cases of incomplete recovery of vision a concentric contraction of the fields down to 10° in each meridian, with good central vision, has been found. Lagrange and Abadie each has reported such cases, and Engelmann, describing a similar case, correctly called it double homonymous hemianopsia with preservation of a small central field in each eye. A homonymous hemianopsia on one side, followed later by a homonymous hemianopsia on the other, with preservation of a small central field in each eye, has been observed repeatedly in patients with advanced arteriosclerosis, the bilateral cortical or subcortical hemorrhages or thromboses sparing some of the fibers serving central vision.

"In many cases of blindness in eclampsia we must suppose that there is an edema affecting the calcarine cortex or the optic radiation on each side, which in some cases causes destruction of tissues and therefore produces permanent defects in the fields of vision."

Francis (*Trans. Am. Med. Assoc.*, 1914) reports two cases of retrobulbar neuritis associated with acetonuria. No other cause could be found for the changes in the visual field. While retro-bulbar neuritis in diabetes as a rule occurs in patients past middle life and broken down in health, in both of these cases the patients were young and especially healthy. In one of these the fields for white were normal, but there was a total lack of recognition for red about the fields of fixation. The blue field was normal. Both eyes were affected. In the second case the visual field of the right eye was normal, while in the left eye white and blue were normal but there was a central scotoma for red.

It is not unlikely that excessive coffee drinking may induce amblyopia. In this connection Casey A. Wood (*Oph. Record.*, March 1915) reports a case of Mettler's where the excessive drinking of coffee, sixteen to eighteen cups a day, brought on a polyneuritis with marked blurring of the vision. Unfortunately no accurate tests of the vision were made. In this article Wood refers to Hutchinson's case (*Centrabl. für pkt. Augenh.*, 1887) of caffein amblyopia in which the symptoms were much like those of quinin intoxication.

Wing (*Annals of Oph.*, Vol. 12, page 232) reports a case of red-green blindness as a result of excessive coffee drinking. These cases are rare, and in view of the universal consumption of coffee the predilection of caffein for the papillo-macular bundle in the optic nerve

cannot be very great, but from the more or less reliable reports in literature there can be no doubt that such cases occur.

THE VISUAL FIELD IN CEREBRAL TUMOR AND OTHER BRAIN LESIONS.

The object of this division is not a general discussion of intracranial tumors and other brain lesions, but rather a brief consideration of the visual disturbances which frequently accompany them, and further, some insight into the value of the field of vision and the pupillary reflexes in the localization of such lesions.

The disease processes to be discussed may be considered as, 1st—*Focal,* producing increased intracranial pressure such as tumor, syphilitic and tuberculous growths, aneurysms, cysts and abscesses; and 2nd—*Diffuse,* not producing increase of intracranial pressure, as hemorrhages and softenings.

Both of these processes may be attended by symptoms that indicate to a lesser or greater degree the position of the diseased area. These symptoms, so far as they affect the eye—usually as optic neuritis and visual field changes—are, as a rule, of no localizing value when taken alone, but may, in conjunction with the reflex pupillary changes, together with the correlated evidence of other ("distant") symptoms, (Fernwerkung) serve quite definitely to determine the seat of the lesion.

These "distant" symptoms are not the direct result of the injury brought about by the tumor, or other brain disease, but may be the evidence of its resulting pressure, or the result of circulatory disturbance, or to reflex inhibition or irritation.

The reader must well bear in mind in considering the field changes in such pathological processes, that these field changes, or other possible accompanying symptoms, are not always found present in the presence of such growths or diseases, and that the gravity and extent of symptoms present are not always to be taken as an index of the extent of the brain lesion. In other words grave intracranial lesions may afford little indication of their presence so far as the fields are concerned, and contrary-wise marked field involvement may exist with small growths, or areas of hemorrhage or softening. Often eye symptoms serve to indicate the presence, but not the position, of the intracranial lesion. For systematic study we may consider the field changes as they arise from lesions involving the chiasm, the tracts, the primary optic ganglia, the internal capsule, backward to the subcortical areas and finally the higher cortical areas of the brain.

The optic chiasm. One of the most interesting of all changes to be

observed in the visual field, that of bitemporal hemianopsia, most commonly arises from disease processes occurring at the chiasm, and is thought by many to be a symptom so highly suggestive of hypophyseal disease as to be considered pathognomonic.

Bitemporal hemianopsia arises as a direct or indirect result of organic disease only, not occurring in functional disease states. The proximity of the chiasm to the sella turcica and its contained pituitary gland makes chiasmal disease almost, although not entirely, synonymous with disease of this gland, and the peculiar field changes found result usually from an actual neoplasm, or a non-neoplastic enlargement of the gland itself. Thus it has come about that much is due to the ophthalmologist for our knowledge of disease of the pituitary body, and this in large measure, it may be added, is of very recent date.

Cushing (*The Pituitary Body and Its Disorders*) speaking of the visual manifestations of hypophyseal disease says: "These are the most common, and naturally to say, the most serious of all neighborhood signs, however, neither is disease of the pituitary body the only cause of bitemporal hemianopsia, nor is bitemporal always the expression of pituitary disease." Regarding the first of these statements Fuchs reports cases of bitemporal hemianopsia occurring in tabes. These are uncommon and he has seen but six cases. This form of hemianopsia is indicative of a lesion of the decussating fibres situated at the inner side of the chiasm, and local inflammation at this point in tabes he ascribes as the cause, just as syphilitic inflammation at the same place may likewise cause bitemporal hemianopsia.

Regarding the second statement, while bitemporal hemianopsia is almost pathognomonic of chiasmal disease, it cannot be said the hypophyseal disease always shows itself in the field as a bitemporal hemianopsia. Cushing, in analyzing the perimetric deviations in a group of cases of hypophysis disease, says, "Some disturbance of the fields has been demonstrated in all but two of the twenty-three patients showing pronounced neighborhood symptoms. However, the supposedly typical bitemporal hemianopsia with a vertical meridian which bisects the macula is conspicuously rare in the series."

Three only of such symmetrical bitemporal field defects were found. Cushing believes that homonymous defects, or tendencies, in this direction are at least half as frequent as bitemporal ones. Indeed, he thinks it possible that they may be quite as frequent, since the cases of bitemporal hemianopsia with hypophyseal cause are more often referred to him than when the disease shows field changes which are homonymous, so that many of the latter, although really connected with pituitary disease, would not be brought to his attention.

Again this writer states that in hypophyseal disease unilateral amblyopia may occur with little or no perimetric deviation in the other eye.

The primary field defect usually involves the color boundaries alone in one upper temporal quadrant followed by more or less complete temporal hemiachromatopsia. In all cases the color-fields are involved first, the form-fields later. The macular region is spared for a long time, but this finally enters the blind area and likewise the entire nasal field. Cushing finds that rarely are the fields affected in equal degree, and that after operation restoration occurs in reverse order, and therefore those cases in which the vertical meridian bisects the point of fixation are simply accidental, inasmuch as they are caught just at that period in the progress of the disease when the blind area is passing nasal-ward.

Fisher (*Trans. Oph. Soc. U. K.*, 1911, XXXI) and Josefson called attention to the fact that the temporal field, at least for form appears to be lost from above downwards. Cross (*Trans. Ophthal. Soc. U. K.*, Vol. XXXI, 1911) has also found this course in the field encroachment, and states that it is invariable. Both Cross and Fisher find small islands of vision may be retained in the blind areas even after loss of the greater part of the temporal field. Cross states that he has never found absolute blindness, there being some of these small areas in every case.

De Lapersonne and Contonnet have noted similar areas. Fisher and Cross seldom found macular division in the vertical meridian. Galezowski has reported meningitis affecting the chiasm, with the field showing temporal hemianopsia, and in one case irregular nasal hemianopsia.

It is possible for bitemporal hemianopsia to remain practically stationary for many years, and even with improvement in the central vision and slight diminution of the hemianopsia itself. This is illustrated by Zentmayer's case regarding which Spiller remarks that he has known other cases of the same character, and offers as an explanation that the tumor in this lesion may by pressure upon the sella turcica wear the bone away, or by involvement of the brain above pressure is in this way on the tracts, and the chiasm is possibly relieved. Spiller cites Packer's case of acromegaly in which there was hemianopsia, and at the autopsy there was found a greatly enlarged sella turcica. Excepting these cases of Zentmayer and Packard, Spiller states he knows of no others of bitemporal hemianopsia arising from grave organic disease where the blind area regained vision after a lapse of many years.

While some observers state that no authentic case of binasal hemia-

nopsia from chiasmal disease has been recorded, Wood (*Oph. Rec.*, March 1908) has reported a case of probable pituitary tumor in which the hemianopsia was binasal.

W. T. Shoemaker (*N. Y. Med. Journal* and *Phila. Med. Journal*, Feb. 4, 1905) thinks that binasal hemianopsia cannot arise from disease of the chiasm, but that it is in most cases a symptom of optic nerve disease. He alludes to the cases of binasal hemianopsia reported by Land and Beevor, Graefe, Daae, Herschel, and Mooren as true cases of binasal hemianopsia, and states that but eighteen cases have been reported in literature. Binasal hemianopsia may arise from a simultaneous lesion affecting the non-decussating fibres at each lateral chiasmal angle, as in atheroma of the internal carotids (Weeks: *Diseases of the Eye*). It is theoretically conceivable in degenerative changes involving both optic nerves than at accidental and coincident involvement might bring about such symptoms. The deliminating line in these cases is not very exact.

De Schweinitz (*Diseases of the Eye*, p. 687) says that a true chiasmal variety of binasal hemianopsia probably does not occur and that most of the cases are due to a bilateral inflammation of the trunks of the optic nerves in front of the chiasm.

A unilateral nasal hemianopsia may arise from disease at the lateral portion of the chiasm involving the non-decussating fibres of one eye only. Homonymous hemianopsia may arise from disease situated in the occipital lobe, the optic radiations, the internal capsule, the primary optic centers, or the optic tracts.

Uhthoff (*Trans. XVI Int. Cong.*, Buda-Pesth, 1909) in a series of pituitary growths affecting the chiasm found unilateral, or bitemporal, hemianopsia in 30 per cent. of those without acromegaly, and in 43 per cent. of those with. He found homonymous hemianopsia occurring in 1.8 per cent. of the former, and 4.3 per cent. of the latter. These cases—in order that dependable fields be obtained—should be tested on a Bjerrum screen with small test objects. Rönne found, in a case with loss of the temporal field in the left, and full field in the right, by the ordinary perimeter, that there appeared with the Bjerrum test an almost complete loss of the temporal right field with a comet-shaped scotoma extending from the blind spot to the fixation point. This writer has found bilateral quadrant nasal anopsia in which the horizontal definition was so sharp that he regards it as proof that the uncrossed fibres exist as two distinct bundles at the chiasm. Thus while chiasmal disease often shows itself as a binasal field defect, it is to be observed that the character of the field found depends in no small degree on the time in the course of the disease that the fields

are taken, for we may have all pictures from a central scotoma, simulating a toxic amblyopia early in the disease, to an almost complete field obliteration; also, in certain cases, as pointed out by Cushing and others, temporal hemianopsia is not characteristic of hypophyseal disease.

In the absence of the characteristic symptoms of acromegaly, the ocular signs, especially the visual field, together with radiographs, are of the utmost importance in the diagnosis of pituitary disease. De Laparsonne and Contonnet have reviewed 80 cases, finding bitemporal hemianopsia in 21 per cent. and unilateral hemianopsia in 11½ per cent. They failed to find binasal, altitudinal and left homonymous hemianopsia. De Schweinitz, quoting these authorities, states that right homonymous hemianopsia has been recorded three times.

Hirsch (*Klin. Monats. f. Augenh.*, XLIX, 1911, p. 749) rests the diagnosis of hypophyseal disease on three cardinal symptoms: bitemporal hemianopsia, the appearance of the patient, and the skiagram. The presence of the bitemporal hemianopsia with one of the other two symptoms renders the diagnosis highly probable, and he thinks if both the other symptoms are present with the visual defect the diagnosis is certain. As other symptoms may be mentioned blurred vision (even where perimetric examinations fail at first to detect the scotoma), central scotomata—already spoken of in this article—scotomas of a hemianopic type, or para-central scotoma, and loss of color-sense preceding the loss of the form-sense.

Swanzy states that bitemporal hemianopsia, unlike homonymous lateral hemianopsia, is almost always accompanied by diminution of central visual acuity. In certain arrested cases of circumscribed meningitis, periostitis, or hyperostoses that have destroyed the decussating fibres, the bitemporal hemianopsia may remain as a permanent symptom. In chiasmal disease one field may be entirely obliterated before the other nasal field is affected.

Transitory recurrent bitemporal hemianopsia may occur in disease of the chiasm, and this Oppenheim (*Berlin Klin. Wochen.*, 1888, p. 584) regards as a sign of basilar syphilitic lesion.

Horizontal hemianopsia may follow lesions of the chiasm from pressure from above or below, and such may show in the course of their progress quadrant anopsias. Such field changes may arise from symmetrical cortical lesions. It is to be noted here that the vertical limiting line in a temporal hemianopsia does not always pass through the point of fixation, sometimes falling short as in incomplete temporal hemianopsia, and again passing beyond, and thus presenting a condition

termed the overshot field of vision, which condition supports the theory of the double cortical representation in the macula. (See Fig. 48.)

While in temporal hemianopsia due to hypophyseal disease the vertical limitation of the blind area changes gradually, passing nasalwards into complete blindness, in temporal hemianopsia due to other disease this line may have an enduring character. Förster (Graefe-Saemisch *Handb. d. gesamt., Augh.*, VII, 116) had a case in which no change in the form of the field occurred within ten years observation

Wilbrand (Norris and Oliver's *System of the Diseases of the Eye*, vol. 2, page 266) says "If a limited portion of the center of the dorsal

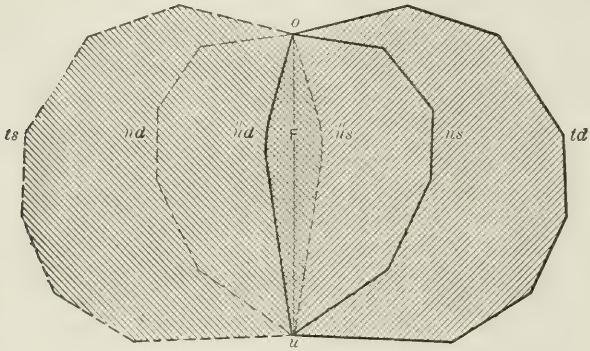


Fig. 48.
Showing Overshot Visual Fields from Symmetrical Cortical Lesions.

surface of the chiasm is altered by a diseased process at the point where the papillo-macular fibres from the fasciculus cruciatus lie at the surface, and interlace them, every lesion is followed by a paracentral scotoma in the temporal halves of the visual field to the outer side of the fixation point in each eye." Such scotomas may increase until the entire temporal halves are included. Again, in the clearing-up process of temporal hemianopsia such areas may appear as temporal hemianopic scotomas.

It is interesting in this connection to note the possible improvement, or complete recovery, in temporal hemianopic fields. De Schweinitz (*Penn. Med. Journal*, April, 1912) reports complete blindness lasting twelve days in the right, and six weeks in the left, eye with complete recovery in the right, and nearly complete in the left, in a case of pituitary tumor, after the use of thyroid extract and mercurial inunctions. Under the same treatment (*l. c.*) complete blindness of right eye, and nasal hemianopsia in the left, entirely recovered. The surgical aspect of this question will be later discussed herein.

It is to be remembered that in chiasmal disease, we may have an associated glaucoma, or an associated functional nerve disease, which may cause peripheral concentric contraction of the remaining nasal halves; also it is to be remembered that syphilitic disease attacking the chiasm may spread to the tracts, and bring about irregular field defects which obscure the diagnosis of chiasmal disease. After a lateral half of the chiasm is destroyed, complete blindness occurs on that side with temporal hemianopsia in the other eye. In typical cases of temporal hemianopsia the binocular field is diminished to each outer side. It must, therefore, be evident that the earlier views which so strongly accented the value of bitemporal hemianopsia, with the vertical meridian passing through the point of fixation, as the cardinal symptom of hypopysis disease must be modified, since this is not always present, and may be, in many cases, an accidental expression of the disease at a certain time; first of the disease, which, early or later may show as a marked overtreading into the nasal, or as an incomplete hemianopsia in the form of hemianopic scotoma, or later as hemianopic scotoma being a residual phase in the process of field restriction.

Relative to this matter of variability the writer will avail himself of the excellent work of de Schweinitz and Holloway. These investigators writing upon the visual field defects, with special reference to scotoma, appearing with hypophysis disease, think that insufficient attention has been paid to "certain localized visual field defects to wit: scotoma, central, para-central and peripheral." They think it a mistake to fix the attention too definitely upon bitemporal hemianopsia as a typical hypophysis disease field, especially since lateral and nasal hemianopsia may occur.

Cushing and Walker in a study of 200 cases state that actual hemianopsia was observed in 34 per cent. Of all cases showing perimetric deviations, and in 12 of the 42 cases which showed hemianopic defects, there was a tendency toward binasal blindness, consequent upon advanced secondary atrophy. In a later series of 100 cases the authors found five additional cases of this form of field distortion, and it is with this type of perimetric deviations that the present communication deals.

In the former papers the authors described two cases in which it was shown that as the secondary atrophy progressed toward ultimate blindness the fibres which resisted the advancing process for the longest time originated from a small area in the nasal retina adjacent to the macula. In a portion of their present 100 cases the authors were able, by consecutive perimetric examinations, to observe the progressive

changes leading up to this condition. The following conclusions are drawn:

"A constriction of the field of vision due to a destruction of fibers more complete from the temporal than from the nasal half of the retina and justifying the designation of nasal hemianopsia has been observed in from 5 to 15 per cent. of a series of 300 cases of brain tumor.

"It occurs as a late sequel of an advanced choked disc in the stage of recession of the edema; and a bilaterally symmetrical process, implying an equal degree of involvement of the two eyes, suggests as a rule a distant, often a cerebellar, lesion with secondary hydrocephalus.

"An internal hydrocephalus with distention of the third ventricle crowds the optic nerves downward and outward against the carotid vessels which transversely indent the outer aspect of the nerves. In this way the uncrossed fasciculi to the temporal retinæ, and the laterally placed macular bundle as well, suffer from a mechanical pressure 'block' in addition to the diffuse anatomical destruction of fibers throughout the nerve in consequence of the contraction of the new-tissue formation in the long-standing choked disc.

"A similar involvement of the uncrossed fasciculi in the absence of tumor may occur, as originally suggested by Knapp, through the pressure effects of diseased and sclerosed vessels. In this event the coincident constriction of the fields shown by our series of tumor cases would hardly be expected, owing to the fact that with cerebral arteriosclerosis a choked disc, though common enough in moderate degree, rarely advances to the stage which we have shown to be associated with the form of binasal hemianopsia under discussion."

Compression of tumor on the chiasm, tracts and optic nerves vary the visual field defects constantly, as pointed out by Kleign.

De Schweinitz and Holloway make the following classification of scotomas found by them in this disease of the pituitary body:

(1) Small para-central scotoma that may upon increase of growth expand into complete hemianopsias. With these may be associated large scotomas in the temporal field.

(2) Absolute or relative quadrant-shaped scotomas, bilateral in one eye and associated with small central scotomas in the opposite field.

(3) These scotomas may vary from day to day, or week to week, in size and position; may be for a time present, then disappear. It may happen that more or less typical visual field defects may disappear upon treatment, and again return in the form of large central scotomas. In support of this is Lauber's (*Klin. Monat. f. Augh.*, 1910, XLVIII, p. 201) case with left complete amaurosis and right temporal hemia-

nopsia, with recovery complete of both after mercurialization. Optic atrophy was evident. Some months later vision diminished in the presence of large central scotomas. Other variations cited are those of Koecher (*Deutsch. Zeitsch. f. Chir.*, 1909, c. 13) with contracted form fields, color hemianopsia and central scotoma; and of Bartels (*Zeitsch. f. Augenh.*, 1906, XVI, p. 407) with form and color contraction and central color scotoma.

(4) Large para-central absolute scotomas in the outer halves of the fields, or sometimes absolute in one and relative in the other.

(5) The appearance of a scotoma near the point of fixation, which may be manifiest some considerable time before the entire field is obliterated.

(6) Blurred vision before the appearance of a scotoma, even when most searching examination fails to reveal the scotoma.

The gist of this matter is simply this: the different field phases are revealed each in the different phase of the disease, and whether this observer finds simply a scotoma of a particular type, or another finds a more or less completely characteristic bilateral hemianopic scotoma field, or an actually typical bilateral temporal hemianopic field, depends probably upon the time at which each observer examined the case. Of course, this does not necessarily apply to all cases of hypophysis disease with field changes. It is not to be forgotten that in basilar cerebral syphilis remarkable fluctuations of the field may also occur, in fact almost any field changes may present themselves, for example complete blindness changing during restoration into temporal hemianopsia, nasal limitation, irregular field defects, all of which arise from tract involvement, as well as from chiasmal disease.

Sell (*Inaug. Diss.* Leipsig, 1894) has collected more than 60 cases of pressure on the chiasm from tumor exudations and granulations with no visual changes manifest.

The optic tracts. The first field manifestation of disease involving the optic tract is a homonymous lateral hemianopsia right or left according to the tract involved; but it is to be remembered that it is impossible from this symptom alone to base a conclusive diagnosis of tract lesion. These bilateral hemianopic defects may be incomplete, and may even assume the form of bilateral quadrant anopsias. It is possible in the beginning of tract disease to find the field defect a monocular one. In pure and complete tract lesions, complete homonymous hemianopsia with the color limits of the normal halves coincident with the form limits are to be expected. In incomplete form-fields the color-fields do not retain so close a relationship.

As regards the interruption, or non-interruption, of the dividing line

Lenz (Graefe's *Arch.,* Bd. LXXII, 1909) and Best (*Ibid,* Bd. LXX, 1909) think the dividing meridian bisects the point of fixation, that it is not quite vertical, but corresponds to the physiological line of separation of the retinal halves. On this position of the dividing line Behr expresses a contrary opinion.

Macular exclusion in hemianopsia has been frequently discussed in literature with no final agreement as to its etiology. The principal theories have been (1) v. Monokow's, which states that there is no cortical center for the macula. (2) Wilbrand's theory, which consists of a double supply of the macula by means of a bifurcation of each macula fiber in the chiasm. (3) Hirschberg and Schweigger explain exclusion of the macula by an extension of retinal fibers to the opposite side of the retina. (4) Rönne believes that when the hemiaopsia is sufficiently marked to abolish the vision in the periphery, the macula fibers being much more acute in function, would functionate sufficiently to cause the macula exclusion to appear in the visual field. The author shows 27 cases of hemianopic fields in which the vision is more acute on the healthy side of the macula than on the affected side.

Wilbrand thinks the tract lesion can only be located when the field changes are considered in connection with concurrent symptoms. He recapitulates the diagnostic points in tract hemianopsia as follows:

"(1) The optic tract may be affected by itself.

(2) It is impossible to conclude that there is a tract hemianopsia from the form of the hemianopic field of vision alone.

(3) If to a homonymous hemianopsia is added a failing of the visual acuteness of one eye, with a corresponding change in the retained half of the field of vision of this eye, the disease process has spread to the chiasm.

(4) If nasal homonymous hemianopsia is found in one eye and blindness or a high degree of amblyopia in the other, then a disease of the tract on the side of the nasal hemianopic defect of the field of vision is probable.

(5) The loss of only one-half of the field of vision of one eye of a hemianopic character, soon followed by the loss of the homonymous half of the field of the other eye, indicates a tract hemianopsia in which the seat of the disease is near the chiasm.

(6) The bilateral appearance of incomplete, homonymous hemianopic defects, which point to tract hemianopsia, indicates that the point attacked in the tract is situated centrally at some distance from the chiasm.

(7) Weakness of one or more cerebral nerves on one side of the body, with loss of the homonymous halves of the visual fields on the other

side, sometimes followed or accompanied by hemiplegia or anesthesia towards the side of the hemianopic defect, indicates disease of the tract. Often polyuria is associated with these conditions.

(8) Hemianopic pupil reaction in homonymous hemianopsia indicates disease of the tract.

(9) A slow development of homonymous defects indicates disease of the tract, while hemianopsia which appears suddenly (particularly in previously healthy patients) is often caused by intra-cerebral hemorrhages and emboli. Hemorrhages into the tract are mostly of a capillary nature.''

The value of the pupillary reflexes in localizing tract lesions is to be later considered in this division. By incomplete blocking of the tract function the half-field defects may be only relative with hemiachromatopsia existing with the loss of the form-fields. Swanzy states that optic atrophy on that part of the papilla on the side of the diseased tract may be found, which is a very rare condition when the hemianopsia is of central origin. Kipp believes that the hemianopic form of scintillating scotoma has its origin in the tract, or external geniculate body.

The primary optic ganglia. The medial root of the optic tract has no connection with the retina or optic centers, but the lateral root terminates in the pulvinar (posterior part of the thalamus), the lateral geniculate body and in the superior colliculus of the corpora quadrigemina, and thus it may be seen that pressure, or tissue disintegration about the fibers of this root in the pulvinar or lateral geniculate body, may produce field changes. This is probably not so in the case of the corpora quadrigemina, as this is probably not concerned with the visual function but with the pupillary reflexes alone. Destruction of the pulvinar can exist without hemianopsia, but Swanzy says ''It can not be denied that lesions of the internal capsule and of the pulvinar are very frequently attended by hemianopsia, and hence, although this symptom here is a distant one due to the great liability to pressure on the visual path (external geniculate body), which is so often present—it must in a sense be reckoned as a symptom of these lesions. There are indeed two symptoms, which, when they occur together, are regarded as typical of a lesion of the pulvinar, namely—athetosis (caused probably by irritation of the motor path in the internal capsule), and hemianopsia. There is often also hemianesthesia.''

While formerly held that the corpora quadrigemina were concerned with sight, the consensus of opinion now is that tumors of the ganglia cause no blindness.

It seems to be well agreed that lesion of the lateral geniculate body

gives rise to hemianopsia. Henschen states that the dorsal portion of this body supplies the upper half, and the ventral supplies the lower retinal half, hence quadrant anopsias may signalize disease of a lateral geniculate body. Henschen (*Neurol. Centralb.*, March 1, 1898) found at post-mortem destruction of the dorsal half of the right geniculate body alone, without injury to any other part of the visual tract in a case that had shown pure left lower quadrant hemianopsia.

The cortex and sub-cortex. While the mesial surface of the occipital lobe has generally been accepted as the portion concerned with the function of seeing and recognizing, just what extent of this surface is so concerned has been a matter of disagreement. For our purpose it is only necessary to state that while not in full agreement with many observers, the views of Henschen are acceptable as a basis of explanation of certain cortical field anomalies, and have, in some cases at least, the corroboration of the pathological findings. Henschen thinks that the upper part of the retina is represented in the superior lip of the calcarine fisssure, and the lower part of the lower lip, and that a horizontal retinal part between these two is represented in the posterior part of this fissure.

Mills (Posey and Spiller, *The Eye and Nervous System*) states that cases of purely cortical and nearly pure cortical hemianopsia, or anopsia, are extremely rare, and refers to those of Wilbrand and Sänger, Holm, Helden and Eggers. This is so, for in lesions of the brain it is rare to find disease strictly limited to the cortical cinerea, almost invariably involving the cortex and sub-cortex. With the view of Henschen in mind, these incomplete quadrant anopsias in which a little less than the quadrant are lost—a ribbon-like area along the horizontal meridan—are suggestive of cortical lesions.

In double bilateral hemianopsia the entire field is lost, usually with a small central area remaining. In these cases the calcarine fissure is involved.

Swanzy says "In cases of hemianopsia due to a lesion of the cortex alone we are mainly guided in our localization by negative signs—the complete absence, namely, of any concomitant paralytic symptom such as hemiplegia, hemianesthesia, hallucinations, and hemiopic pupil. The one positive sign of this cortical lesion is, oddly enough, negative vision, the 'vision nulle' of Dufour. The patient in these cases sees 'nothing' in the defective part of the field; he is, in fact, as unconscious of his defective sight in half of his fields as a healthy person is of the existence of the normal blind spot. On the other hand, if the lesion be in the visual path, a subjective sensation of darkness or of blackness is referred to the defective halves of the field of vision, and in these

instances the patients frequently call the attention of the surgeon to their defect.''

Evans (*Ophthal.*, Jan., 1912) says ''The typical field due to lesion of the visual cortex is a homonymous hemianopsia with overshot boundary line, and preservation of the macula.'' However, such symptoms may arise from lesions in the optic radiation as well.

Dyschromatopsia in disease of the intracranial visual paths. This is a matter of the keenest interest, and has properly been omitted in the separate paragraphs that it might be collectively treated here.

Until more recent times the symptom of dyschromatopsia has been held as singularly, if not almost exclusively, one relating to the hysteric state and the psycho-neuroses. That this phase of change in the visual field may have some diagnostic significance in actual organic brain disease is now admitted.

Bordley and Cushing (*Arch. of Ophthal.*, XXXVIII, 1909) have for a long time studied the color-field changes in cases of brain tumor and find the following changes in the fields as predominant symptoms: interlacing of the color lines; color-inversion; remarkably constant and significant changes in the blue field; hemiachromatopsia with the corresponding changes in the form-fields; islands of blue-blindness; complete blue-blindness; complete green-blindness.

These observers find non-correspondence in the form and color-fields remarkably frequent as compared with our usually accepted ideas, and report 56 cases of brain tumor in which the fields showed color changes, and of these only 18 showed changes in the field for form. We cannot ascribe this series of findings, which are usually very different from those heretofore accepted, to any lack of care or detail in technique, or absence of the Bjerrum test, of which the observers availed themselves, and the results are all the more interesting as inviting our attention to color changes in brain tumor as a possible feature of great diagnostic importance. These writers make the assertion, however, that almost all cases of brain tumor coming under observation have at one time or another been regarded as hysteric, or afflicted with some psycho-neurosis. This is quite remarkable, and possibly may introduce an element that may bear somewhat upon the frequency of their finding of color changes in brain tumor. The changes in the blue field contrast markedly with the visual field changes in tabes, sclerosis, etc., where we find the red fields the ones usually affected. Complete achromatopsia occurs in certain cases of brain tumor, and appears to cause greater confusion of sight than concentric contraction. The explanation of this phenomenon of relative cortical hemianopsia, or color hemianopsia, has received much attention. Wilbrand's theory that the

color-sense, the form-sense, and the light-sense are arranged in superimposed strata in the order named, is as yet unproven and is attacked by some.

Regarding cortical hemianopsia, C. K. Mills (Posey and Spiller *The Eye and Nervous Diseases*, p. 84) says, "If the theory of Wilbrand's were true that light and color are represented in the superimposed strata, some forms of it would be explicable on the view that the most superficial layers of the cortex were destroyed. Such destruction might, for instance, cause a hemiachromatopsia, leaving light perception unaffected, but it is fanciful, if not absurd, to reason that any such neatly demarcated destruction of superimposed cortical layers takes place as the result of disease, and, so far as I know, such a case has never been reported."

Mills states that relative cortical hemianopsia is comparatively rare, which does not entirely accord with the observations of Bordley and Cushing (*loc. cit.*), who found approximately 7 per cent. of such cases in their series of brain tumor. Although it goes without saying this does not represent the percentage in true cortical disease, as all of their tumors were not cortical, at least not involving the cortical areas of sight. Relative hemianopsia may simply manifest itself in the diminution of the power of recognizing light, form and color in the affected field. Relative quadrant anopsia may occur in brain tumor, and in one eye may be absolute, and in the other relative.

Changes in the color-field may arise from any disturbance of the conducting fibers concerned with the transmission of color stimula, beginning at the retina and ending at the occipital cortex. Here are situated the separate centers for the fundamental colors. While in chiasmal and tract diseases this color aberration shows in the form of scotomas of different colors, shapes and positions, we find on the other hand when, considering cortical color defects, that the field changes are usually of a homonymous nature—in other words homonymous hemiachromatopsia. Cases like those of Verry and Brill would seem to place the lesions "ventrad to the calcarine fissure, although it also includes this fissure, and a part of the cuneus." (Mills.)

Disease of the visual pathway may affect the patient in such a manner that difficulty is found in differentiating between certain colors; he has a false, or incorrect perception of color. To this condition the term parachromatopsia is applied. Again the patient, while recognizing the color correctly, is unable to name the color thus recognized, a condition designated amnesic color-blindness.

The value of the visual fields and the pupillary reflexes in localization. Many field changes exist which may be easily accounted for by

evident intraocular disease, as pigmentary retinitis, disseminated choroiditis, retinal detachment, etc. These field changes may be monocular, or binocular, and in the case of retinal detachment, may assume forms not unlike altitudinal hemianopsia. In such cases it is usually not difficult to assign to the field defect observed its true cause, but on the other hand, where field defects manifest themselves in the absence of ophthalmoscopic findings, or with such findings that are not differentially characteristic of any certain disease, we must, in such cases, rely upon the character of the field changes themselves together with associated symptoms. Thus in attempting to localize the point of interruption, or "blocking," of the visual pathway, which may occur at any point between the retina and the cortical visual centers, we may arrange the symptoms connected with such processes under three headings: (1) Homonymous field changes; (2) Pupillary reflexes; (3) Associated symptoms arising either at the point of disease, or indirectly at a distance from this point. See p. 4622, Vol. VI, of this *Encyclopedia*.

None of these alone, not even the pupillary reflex, has any absolutely certain localizing value in cerebral disease, but the homonymous field changes, taken together with the pupillary reflexes, are very often capable of rendering considerable definite information in regard to placing the lesion, and again when all three classes of symptoms are present the aggregate of these may give us positive knowledge as to the localization of a growth or inflammation. It is the writer's experience that many of his cases of brain tumor do not come to attention until the taking of an accurate field has become a very difficult or quite impossible matter. As is well known the generally present choked disc has no value in localization in these cases, nor is it even an index to designate the degree of involvement of the brain tissue. The practical questions that usually present themselves for diagnosis are these: (1) On what side of the brain is the lesion? (2) Is it basilar, or involve the mid-regions of the brain; is it in the sub-cortical or ultimate cortical regions? (3) If basilar, or an involvement of the third ventricle or lower stratas of the brain substance, at what point, beginning at the chiasm and extending backwards, is the pressure or destruction?

Before further discussions of these questions it is to be remembered that changes in the orbital portion of the optic nerve may show themselves in the visual field. In such cases the field changes are usually monocular. In primary atrophy of the optic nerve the degree of central visual acuity and the degree of diminution in the peripheral field for white and color bear a regular relation each to the other, which is of some importance in diagnosis. This is in contrast with the field

changes arising from progressive atrophy where the peripheral fields suffer first, as shown by concentric restrictions existing in the presence of good central visual acuity. In the course of the disease, those colors which ordinarily disappear first, as we pass toward the periphery in a normal eye, fade in regular sequence. Homonymous field defects are on the opposite side from the lesion, that is to say, a lesion in the visual pathway of the right side between the chiasm and the cortex, affects the right half of each retina and expresses itself in the loss of the opposite, or temporal, field.

The chief symptom of chiasmal disease is bitemporal hemianopsia resulting from pressure or destruction of the decussating fibers at the anterior portions of the chiasm, which supply the nasal sides of each retina. It is possible, from extension of the disease at this point, that the lateral part of the tract may be involved, bringing about invasion of the nasal field in addition to the already existing temporal defect. The radiograph, together with the field changes, bear strong testimony regarding the localization of the lesion. Involvement of one of the optic tracts causes lateral hemianopsia on the same side. This homonymous lateral hemianopsia, it is to be remembered, may also be caused by a lesion of any portion of the visual pathway posterior to the optic chiasm. The following rules, condensed by Seguin, are of value:

"(a) The lesion in hemianopsia is on the opposite side of the dark fields.

(b) If the preserved fields are accompanied by concentric contraction, the smaller half-field will be in the eye opposite to the lesion; contraction of the preserved half-field is most common with lesions of the cortex, but also may occur in lesions of the tractus.

(c) If the hemianopsia is relative, the lesion is probably in the cortex; but cortical lesions are not excluded by absolute hemianopsia.

(d) A lesion confined to the cuneus, or to it and the gray matter immediately surrounding it, on the mesial surface of the occipital lobe, produces homonymous lateral hemianopsia without motor or sensory symptoms, at least without these as a direct consequence of the lesion, although they may appear as *indirect*, or, as they are sometimes called, *distant symptoms*.

(e) A lesion producing typical hemiplegia, aphasia, if the right side is paralyzed, little or no anesthesia and lateral hemianopsia, is probably due to disease in the area supplied by the middle cerebral artery.

(f) A lesion causing hemiplegia, hemianesthesia, and lateral hemianopsia is probably situated in the posterior portion of the internal capsule.

(g) A lesion causing hemianesthesia, ataxic movements of one-half

of the body, no distinct hemiplegia, and lateral hemianopsia could be situated in the posterior lateral part of the optic thalamus.

(h) A lesion causing the symptoms of disease of the base of the brain, associated at the same time with changes in the pupil, changes in the nerve-head, and lateral hemianopsia, could be situated in one tract or in the primary optic centers on one side.

(i) Incomplete hemianopsia, assuming usually a quadrant-shaped defect, may be present on account of a lesion confined to the lower half of the cuneus. It may also occur with less definite limitations in lesions of the subcortical substance of the occipital lobe and then may be associated with other symptoms, as hemiplegia and hemianesthesia. Finally it may occur from a lesion of the tract, but then will be accompanied by other symptoms indicating basal disease, or from a lesion of the external geniculate body.

(j) A hemianopsia in which there is preservation of the light-sense, but loss of either the color-sense or the form-sense, indicates that the lesion is in the cortex of the visual center."

Purely cortical, or nearly purely cortical, hemianopsias or anopsias are exceedingly rare according to Mills, and he states that a closer examination always shows that the lesion involves the optic radiations somewhere in their course from the pregeniculum to the calcarine fissure and cuneus. Seldom is the sub-cortex normal when the cortex is involved. Autopsy has revealed cases of purely central anopsia and hemianopsia (as note cases of Hunn and of Beevor and Collier already referred to) but they are rare, and are usually cases of tumors growing from the membranes. Wilbrand and Sänger (*Neurologie des Auges*) note many of such cases reported.

In regard to double hemianopsia, the cases reported show scarcely without exception that the lesions were not limited to the cortex, but nearly always invaded the sub-cortex. Cases recorded with autopsy are those of Dejerne and Vialet (*Centralbl. f. pkt. Augenheil.*, Feb., 1894), Schmidt-Rimpler (*Arch. f. Ophthal.*, Nov., 1887), Bouveret (*Rec. Genl. d. Ophthal.*, Nov., 1887), Dunn (*Univ. Mag.*, May, 1895).

In the differentiation of cortical anopsias and hemianopsias, as well as hemianopsia due to lesions of the optic radiations of Gratiolet, the *hemiopic pupillary reflex* ("pupillary reflex of Wernicke") is of value. Regarding this test it is interesting to remember that Ferrier, while experimenting, accidentally cut the tract. He observed that the pupil failed to respond to light carefully focused on the blind half of the retina, while in cases of cerebral extirpation experiments the pupil always responded.

A lesion of the right tract affects the function of each right retinal

half and causes left homonymous hemianopsia and loss of the afferent pupillary reflex passing through this tract, so that when light is thrown upon the blind halves of the retina no pupillary reaction follows. If the lesion is posterior to the tract the hemianopsia exists, but the reflex pupillary arc is intact, and thus both retinal halves of each eye, when stimulated by light, give reflex pupillary reactions. This is known as the hemiopic pupillary reflex of Wernicke.

The Wernicke pupillary test may sometimes serve to place the lesion in the cortex or optic radiations, or to exclude it from them. The reflex occurs if the reflex paths anterior to the primary optic centers are interrupted, and is absent otherwise, i. e., if there be no contraction of the pupil to light from the blind side of the retina, but contraction to light on the seeing side, the lesion is anterior to the primary optic centers. See p. 5769, Vol. VIII, of this *Encyclopedia*.

Henschen (*Klin. Med. Anat. Beiträge zur Pathol. des Gehirns*) believes the hemiopic pupillary reaction is present in tract lesions, even though small or due to pressure; in lesions of the posterior segment of the thalamus and pulvinar; in lesions of the chiasm and in optic nerve lesions with unilateral hemianopsia.

The test is made as follows: The examination should be conducted in a dark room, the patient being seated in front of the source of light, as in retinoscopy, although the light is to be more directly back of the patient in this case. The eye is illuminated by reflected light by means of a plain mirror, and a small beam of light is reflected upon the pupillary space by a concave mirror held in the other hand. The light from the latter mirror should fall obliquely onto the pupillary area.

In hemianopsia if the light so thrown and falling upon both the blind and normal sides of the retina causes contraction of the pupil the lesion is behind the primary optic centers. Again with the light so thrown, if there is pupillary contraction when it falls upon the seeing side, but no pupillary contraction when it falls upon the blind side, the lesion is in front of these centers. It is well known to neurologists and ophthalmologists that Wernicke's pupillary inaction in somewhat difficult to demonstrate, but it is possible to demonstrate it when great care is taken. The writer makes this test with the electric ophthalmoscope and finds it much simplified, but he wishes to accentuate, as others have done, the difficulty of the test.

Rothman, from a study of cases, deduces the following possibilities of a hemiopic pupillary reaction:

"(1) If it is found in an acute case of hemianopsia, the lesion is in the region of the optic tract.

"(2) If in such a case the reaction later disappears, the lesion was

probably in the internal capsule and produced the phenomenon temporarily from a distance.

"(3) If the reaction does not appear, the lesions are beyond the internal capsule.

"(4) If the reaction appears in a long-standing hemianopsia, it speaks for degeneration in the optic tract and primary centers.

"(5) Hemiopic pupillary reaction without hemianopsia means a lesion somewhere between the corpora quadrigemina body and sphincter iridis."

Walker in an elaborate description of the hemiopic pupillary reflex, and of his special apparatus for making this test, concludes by saying:

"(1) A weak hemiopic pupillary reaction may be masked by the pupillometer light when observed consensually.

"(2) Light and dark adaptive phenomena, in addition to dispersion light, seriously complicate the hemiopic pupillary reaction.

"(3) The hemiopic pupillary reaction is definitely present in anterior lesions, when examined by the rotary shutter method.

"(4) The hemiopic pupillary reaction is also present in cases having every clinical evidence of being purely posterior cases, although autopsy examination is necessary to prove absolutely that there is no involvement of the optic tract or primary ganglion centers.

"(5) Although it may be concluded from the examination of these cases that the peripheral retina does possess a weak pupilomotor sensitiveness, there is no evidence that the hemiopic pupillary reaction has any topical diagnostic value."

He further states in this article that "These reactions in their various stages have been found in anterior lesions as well as in posterior lesions. Indeed one of the most striking examples was in a posterior case. The phenomenon has been found in rather early stages of incomplete hemianopsia of both bitemporal and homonymous types. It has been found in tract and chiasmal lesions, both with and without relative central scotoma."

Wilbrand believes the Wernicke hemiopic pupillary reaction a practical failure as carried out, and proposed *a hemianoptic prism phenomenon test*. This test is conducted in the following way: The patient fixes a white point on a large black plain surface. Suddenly two prisms of equal degree (—15°) are brought before both eyes, the apices being turned to the hemiopic defect. If cortical hemianopsia exists the patient's eyes will move so that the fovea is directed to the object. If the reflex pathway is interrupted by a lesion of the tractus, there is no movement of the eye.

In considering the question of the localizing value of field changes,

it is to be remembered that many of the forms of visual field change noted in organic disease are simulated in hysteria and the psychoneuroses.

As reported elsewhere in this article, migrane may be attended with bitemporal and binasal homonymous hemianopsia with temporal scotoma-scintillans, all appearing on successive occasions in the same patient. Vascular changes, often transitory, probably have much to do with these rapidly changing pictures. With bilateral cortical disease we may have right- and left-sided homonymous hemianopsia in the same patient with absolute blindness and if the disease is confined to the cortex the pupillary reactions remain. In these cases the dividing line sometimes escapes the fixation point, permitting central vision of a very narrow tubular type.

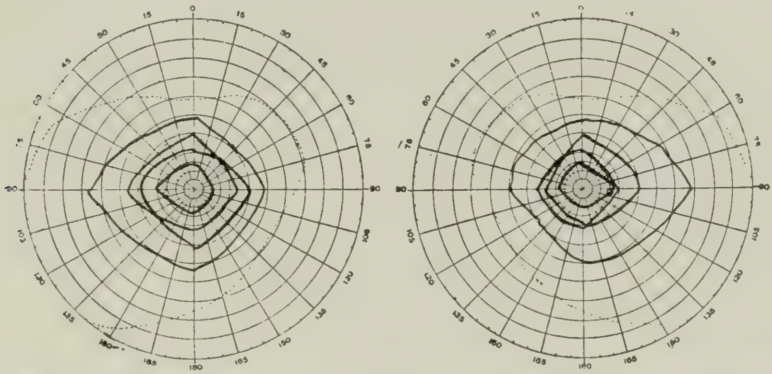
The effect of surgical operations upon defects in the visual field. We are particularly indebted to Horsley, Hirsch, Cushing and Bordley, de Schweinitz and Frazier regarding operative interference upon the cranium in visual field and other defects.

de Schweinitz (*Annals of Oph.*, April, 1911) thinks that time devoted to the administration of remedies is time wasted if brain tumor is present, but that time devoted to accurate observation is never wasted. He thinks in syphilitic optic neuritis a thorough six or eight weeks anti-syphilitic course should be employed before palliative trephining, although Horsley questions whether a gumma of the brain ever disappears entirely under mercurials and iodides, especially if the gumma has been of long standing.

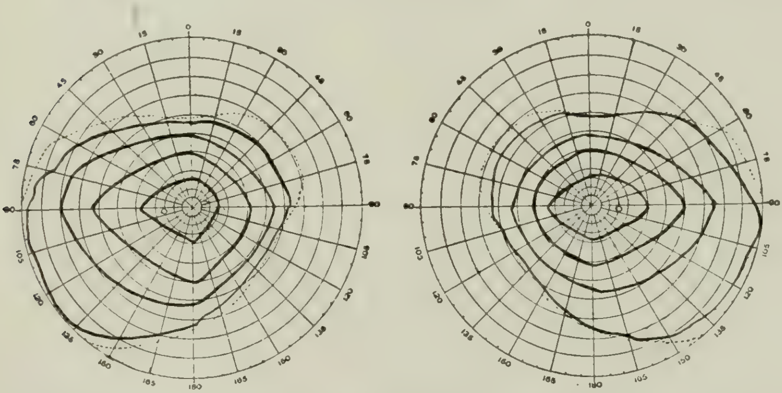
As indicating the changes in the visual field after operative interference in a series of 212 brain operations analyzed by de Schweinitz, improvement or preservation of vision was found in 76.5 per cent. and failure to improve in 23.5 per cent. The earlier the operation is performed—the earlier the diagnosis is made—we may expect the best results in vision following decompression operations, and if the growth is localized and to be removed it is possible to establish a permanent cure. In a certain percentage of the cases of brain tumor seen early, no changes in the optic nerve are to be found, and it is here that the peculiar color-fields, such as interlacing, inversion, or blue-blindness described by Cushing and Bordley, are of great value.

de Schweinitz says "Where reversal and interweaving of the color lines are due to increased intracranial tension, as they frequently may be, decompression is followed by a restoration of the color-fields to their normal sequence, as the charts made before and after an operation by Dr. Frazier well show. (Fig. 49.) I am distinctly of the opinion, however, that there is at present no justification in depending upon this

sign alone as a certain one for recommending a palliative tiephining, because, even in normal eyes, in many cases of cerebro-spinal disease, and in a number of function disorders, exactly similar visual field phenomena are present."



Visual fields, before operation, of patient in service of Drs. C. H. Frazier and W. G. Spiller in the University Hospital, with symptoms of cerebello-pontile angle tumor and with hydrocephalus. Contraction of form fields and partial reversal of color lines. Double choked disks.



Visual fields of same patient seven months after subtentorial decompression. All symptoms had disappeared, and visual fields are practically normal.

Fig. 49.
Cerebral Decompression (de Schweinitz.)

He thinks, however, that it would therefore seem correct to conclude that the most satisfactory treatment for the purpose of preserving vision in any case of choked disc not due to a toxic process or constitutional disease (infectious optic neuritis), but depending upon increased intracranial tension, is cerebral decompression, with, if possible, an immediate or subsequent removal of the growth; that

if operation can be performed early, that is, during the first or second stage, the prognosis as to sight is fairly good; that the statement that one must wait for the appearance of a choked disk before resorting to this operation must be modified in favor of immediate operation, provided such other symptoms as have been described are present and the general and neurological examinations indicate the presence of a lesion that is raising the intracranial tension; and that in non-syphilitic cases time devoted to the administration of iodids and mercurials is time wasted. In later cases of the fourth and fifth stages of choked disk with great loss of central and peripheral vision, the operation of decompression is not indicated and often hastens the onset of the blindness.

Frazier states that it matters not from what portion of the cranium the bone is removed, so far as concerns the effectiveness of the procedure, though he thinks preference should be given to parietal, or temporal, rather than to occipital, or frontal, decompression. In operating to relieve symptoms depending upon pituitary tumor Cushing attacks the base of the sella through a nasal submucous dissection.

THE VISUAL FIELD IN FUNCTIONAL NERVE DISEASES.

The ocular stigmata of hysteria and neuresthenia, as expressed in the visual field, are varied and important, and present sometimes a mere hint, sometimes a form outline, and sometimes a completing background to the picture which, if correctly drawn and intelligently interpreted, give to the neurologist and to the ophthalmologist information which, according to Charcot, is a never-failing guide in unmasking these neuroses and establishing their identity. This is especially so with hysteria and, according to von Reuss, almost equally so in neurasthenia.

In the now classic monograph of Parinaud (Norris and Oliver—(*System of the Diseases of the Eye*), in the excellent work of von Reuss (*Das Gesichtsfeld bei Nervenleiden*), in the work of Baas, in the monumental and exhaustive work of Wilbrand and Sänger (*Neurolgie des Auges*, Weisbaden, 1909), in the work of Frankel-Hochwart and Topolanski (Deutschmann's *Beitrage zur Augenheil.*, 1895), and in the numerous monographs and writings of de Schweinitz the writer has found direct access and desires to acknowledge great indebtedness.

(A) *The visual field in hysteria.* That we can no longer look upon hysteria as a disease simply of simulation or perversion, the visual field lends its strong evidence and support. While no palpable anatomical evidence of this disease, except in a negative sense, may

be afforded by the post-mortem findings, we know that paralysis and conditions as severe and as permanent in duration may manifest themselves as like symptoms arising from demonstrable organic lesions.

This observation *au fond* one referring to *general* manifestations of hysteria very early in the study of this disease apply very forcibly to the visual field, for here almost all the protean characters of hysteria appear in forms that find analogues in other cases in field changes that are the expression of organic disease.

The essential sign of hysteria, so far as the field of vision is concerned, is concentric contraction. This contraction to be correctly designated an ocular stigma of hysteria, must—as accentuated by von Reuss—show itself upon the first testing of each meridian, and not as a sequence to fatigue from examination.

The contraction of functional nerve disease is usually of regular outline, in contrast to the irregular projections that assume the form of sector-like defects, or jagged entrances of the blind area into the field, that occur so often in organic disease. This contraction, although concentric in the sense that it developes from the circumference toward the center in such a way as to form a circular line, may have its greatest restriction on the temporal, the normally greater side, or in the nasal or superior portions of the field. The degree of this concentric contraction may vary from a very slight one to one so extreme that its field limits may lie just outside of the point of fixation. Many hysterical patients have normal central vision, and normal outlines of the field for white, but it has been stated by Pansier (*Les Manifestations Oculaires de L'Hysterie*, 1892), that while the field for white may remain normal there is true enlargement of the color-field (hyperchromatopsia), with or without inversion of the color circles. To this von Reuss, as well as Frankel-Hochwart, take exception, stating that hysteria may have no changes in the field either for form or for color. To this latter view the writer himself ascribes for he has taken the fields of a large number of hysterical patients that have given absolutely normal outlines for both color and form, and in whom, when the tests were immediately repeated, showed no retinal anesthesia or fatigue, as was indicated by the similarity of the fields obtained as compared with the first test.

In some cases the contraction may be so slight as to give cause for doubt as to its identity with hysteria, it being possibly a small physiological field. (See section III.)

In addition to concentric limitation of the fields almost all forms

of defects have been reported although the appearance of hemianopsia as a true stigma of hysteria has been doubted. Regarding this subject Parinaud says "There is, however, one variety of visual sensibility that it (hysteria) appears to be incapable of producing, and that is hemianopia.

Rosenthal (*Wiener Med. Presse,* 1879) stated that in all cases of hysteric amblyopia he had tested temporal hemianopsia existed. This extreme and certainly unsupportable view it seems he subsequently retracted in a letter to Charcot (Gilles de la Tourette). While many cases of hemianopsia have been reported as stigmata of hysteria, notably those of Galezowski, Svynos, Dejerine, Koenig and others, de Schweinitz (Posey and Spiller, *The Eye and Nervous System,* p. 635) says that so far as he could judge "Hemianopsia as an *enduring* ocular symptom of hysteria in the same sense as concentric contraction of the visual field does not exist." On the other hand he admits that as a temporary phenomenon it appears as a bitemporal or homonymous lateral defect, or even as a binasal involvement of the fields. In discussing this question it is of interest to note that Janet (*La Presse Medicale,* 1889) says that these hemianopsias may be stages only in the process of recovery after complete hysterical amaurosis, an observation previously made by Galezowski and Daguenet.

In the same case reported by Zentmayer was noted the occurrence at different times of homonymous lateral hemianopsia, bitemporal scintillating scotoma, ring scotoma, and bitemporal hemianopsia. Fuchs states that the scintillating scotomas of migraine are undoubtedly due to a disturbance of circulation in the cortical centers, and says that when these are unilateral they are to be explained as circulatory disturbances that are purely retinal. The changes throughout this case are evidently due to vascular disturbances occurring in different regions.

We must distinguish the transitory from the permanent hemianopsias in hysteria.

Babinsky (*Arch. de Neurologie,* Nov. 1890) states that a transitory form resembling migraine or scotoma scintillans is sometimes attributed to hysteria. Parinaud speaks of a case in which the patient stated she saw only one-half of objects, but that the field tests gave only an exaggeration of a concentric contraction that had existed before the attack.

The writer has at the present time a case of hyteria that has had several such attacks in which she states that she "sees half of everything." Tests have been made during these periods and nothing

found but a slight concentric contraction. On two of these occasions the pupil of the right eye has been widely dilated. Central visual acuity was 6/6 with negative ophthalmoscopic findings.

The involvement of the field is sometimes so grave as to encroach close to the fixation point, a fact demonstrated through cases reported by Parinaud, Gilles de la Tourette, and Janet as well as by de Schweinitz in collaboration with J. K. Mitchell.

Here in one field the contraction has quite approached within 5° of the fixation point with all loss of color-vision, and in the other

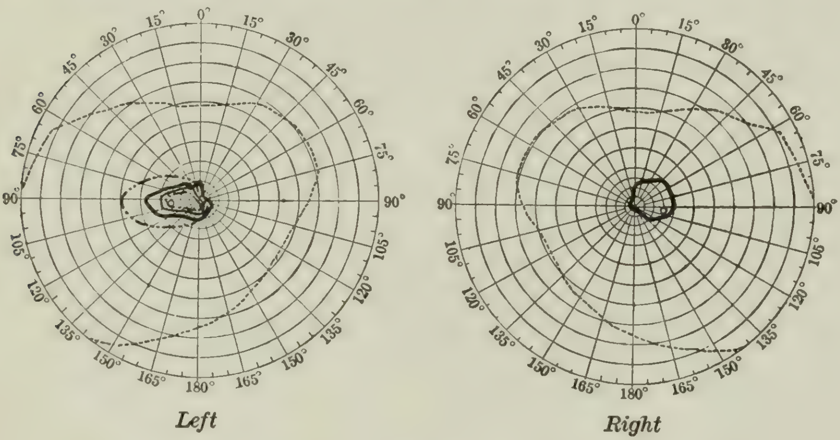


Fig. 50.
Showing Grave Involvement of the Field in Hysteria. (de Schweinitz.)

field grave concentric contraction with partial reversal of the color lines.

Both eyes in these cases of de Schweinitz had "tubular" vision. Binswinger has doubted the existence of such extreme contractions in hysteria.

Charcot (*Lecons sur les Maladies du Système Nerveux*, 1868) and Leber (Amblyopia Hysterica—*Arch. fur Ophthal.*, 1869), assert that the cause of the visual defect lies in the brain, being a functional disturbance of the cortical centers. De Schweinitz (Posey and Spiller *Diseases of the Eye and Nervous System*) says: "It is conceivable that some toxin is liberated during an hysterical attack, and that the retina is poisoned, or perhaps the cortical centers, by this toxin, producing, according to its virulence, a temporary, an enduring, or a long-continued blindness exactly as it occurs in uremia, in diabetes, and in certain intestinal fermentations." He continues "It would be confessedly difficult to reconcile this theory with unilateral ambly-

opia unless one were willing to admit a selective action of the toxin upon the retina, exactly as in very rare toxic blindness—for example, quinin blindness—is unilateral."

One of the odd features of the hysteric field is its long duration, as evidenced by many observers yet not accepted by all as a fact, notably Sachs, Mauthner and Schmidt-Rimpler.

Photometric examinations show, according to Parinaud, that "While it is true that the amblyopia is habitually accompanied by photophobia, and that a strong light sometimes exaggerates the contraction, yet it is not the less certain that the distinguishing mark of this affection resides in a diminution, or a complete abolition, of the faculty of receiving luminous impressions."

This insensibility for white light is usually attended with a like condition for color perception, with attendant color-field contraction. This latter—color contraction—is not, as is the former, always present. Beside the cardinal sign of concentric contraction, Parinaud points out that there is an accompanying spasm of accommodation which forms an integral part of the hysterical affection. The writer has not studied this phase of ocular disturbance in hysteria and he will, therefore, avail himself of the opportunity to quote Parinaud who says: "Among the causes which may modify the extent of the contraction should be first noted convulsive (ciliary) attacks, which exaggerate the amblyopia to the point of producing a temporary amaurosis. We find, then, in general, the visual field more contracted if the patient has had convulsive seizures prior to examination.

"I have observed that in certain subjects we may modify the extent of the visual field by acting upon accommodation with spherical glasses. In some patients, in whom vision was markedly reduced not only by the disorder of accommodation but also by anesthesia of the retina, I have seen the visual acuity return to such a degree that it was impossible to explain the amelioration by the laws of refraction alone. Unquestionably we can modify peripheral and central sensibility in hysterical amblyopia by means of the accommodation. It is true that we sometimes obtain the same result by the application of neutral glasses to the eyes. It would not be necessary to believe this to be due to suggestion—which may nevertheless exist in some instances—or to some mysterious action of the glasses. We must take into consideration the instinctive tendency to relax or contract the accommodation when glasses are placed before the eyes. I believe, with Förster, that the extent of the visual field in retinal anesthesia is modified by the action of atropine.

"The converse is equally true. Excitation of the retina by light

increases contracture of accommodation, especially when there is intense photophobia. We may, perhaps, explain the paradoxical fact that the visual field is sometimes more extended with a reduced light than with an intense light by remembering that retinal sensitiveness is sometimes associated with spasm of accommodation. Smoked or blue glasses also increase the extent of the visual field, as has been for a long time noted.''

Parinaud further presents in this connection the interesting history of a boy ten years of age, who exhibited slight accommodative spasm and slight narrowing of the visual field, and with so little asthenopia as not to necessitate the interruption of his studies. He passed the greater part of the day out-of-doors in the sun-light. His sight became affected, and there was photophobia with vertigo and nausea. These symptoms ceased as soon as he was brought into a dark place. A double spasmodic myopia of eight dioptres was found, the refraction of the eye being hypermetropic and his visual field was contracted from 5° to 6°. Upon the use of atropin for eight days with tinted glasses the spasmodic myopia disappeared entirely on the left side.

It is not to be understood that in those cases of extreme (according to Binswinger, pronounced, when the field is reduced to ½) contraction of the field that this condition is the result of a gradually concentric contraction. For on the other hand such marked defects in extreme cases amounting to total extinction of the field may appear suddenly. The concentric contraction in hysteria is usually bilateral, but may be unilateral.

Parinaud states he found eight unilateral cases in 75 examined.

Morax (*Arch. de Neurologie,* 1889), out of about the same number of cases examined at the Salpétriere—88 cases examined—found eight cases of unilateral amblyopia, or amaurosis, and found in cases where amblyopia or amaurosis was complete in the one eye that the field for form and colors was abnormally large in the other.

It is then to be seen that concentric contraction is generally accepted as the most common stigma of hysteria as manifested in the visual field, and von Reuss states that among anomalies of the hysteric field of vision two are dominant, the first, concentric contraction, the second, the so-called ''oscillating field of Wilbrand.''

This ''oscillating field'' is a peculiar field anomaly in which on the same meridian under test the object disappears, again to reappear, and after a short streak, again disappears and again reappears.

As evidence of the hysteric nature of the field the ''shifting type'' described by Förster: the ''exhaustion type'' of Wilbrand; the ''type with unstable concentric limitation;'' the ''exhaustion spiral type;''

and the "recuperative extension type" of the visual field have been presented. It is to be noted, however, that these five types so carefully classified and elaborated by von Reuss are not truly hysteric stigmata, but are more correctly related to neurasthenia, and under this heading will be later considered. It is to be remembered, however, that the oscillating field already described is believed by von Reuss to be a true hysteric phenomenon.

The field in hysteria may suffer contractions from emotions, excitement, depression, and suggestion. Janet expresses the view that the effort of visual attention alone may contract the field. While dating from the earlier investigators, Förster, von Graefe, Schweigger and others, the explanation of this phenomenon of shifting and variability of the field was ascribed to retinal anesthesia (Steffan, hyperasthesia), and even by recent writers to rapid change in retinal sensitiveness, or retinal tire, and it may not be forgotten, as pointed out by Schmidt-Rimpler and others, that the ever-varying results occurring during a perimetric examination are not always retinal, but may be cortical evidences of diminished, or disordered, function, or due to psychic visual fatigue.

It must, with these facts in view, impress itself upon us, the importance of interpreting any certain charted field of hysteria in the added light which certain factors of control that present themselves in the form of the peculiar emotional state the patient finds himself in at the time of examination, as well as the possibly greater than usual effort of visual or psychic concentration, and the matter of suggestion. It becomes clear, however, as we study the ocular signs of neurasthenia, that we find in the peculiar evasiveness and instability of the retina, or the cortical areas related to it as shown in the many peculiar field eccentricities which we designate "types," symptoms which, associated with others, are peculiar to this disease. In hysteria this does not so fully apply, for while the essential sign, concentric contraction, is the rule the field changes are, like the disease itself, protean in form. In hysteria the field change is usually one that appears at once, and does not ensue upon the fatigue following wearying examinations with their attendant visual effort that is so notably the case in neurasthenia, also the field is apt to be more lasting in its outline than in neurasthenia. If, however, we accept from von Reuss the "oscillating field" as one peculiarly worthy of being recognized as related alone to hysteria, we find a field in some features not unlike the more variable types he ascribes to neurasthenia alone. As pointed out by von Reuss the peculiar "breaks" and "makes" on the meridian of the so-called

"oscillating field" if connected by more or less perfect circles form double or multiple ring scotomas.

The oscillating feature of this field is also observable for color. In the case first reported by Wilbrand (Wilbrand and Sänger, *Uber Sehstörungen bei Functionellen Nervenleiden,* 1892) the phenomenon was associated with concentric contraction, but in the three cases of Koenig normal boundaries of the fields were present (*Deutsche Zeitsch. f. Nervenheilkunde,* VII, 1895). In regard to the so-called ring scotomas resulting from a connection of the corresponding broken lines in the different meridians, Koenig expressly states that he is justly aware that these are not true scotomas in the usually accepted sense. Von Reuss states also that the concentric contraction of hysteria is not such in the usual sense, since in it the orientation of the patient is not affected; these ring scotomas do not affect the sight of the patient since they do not appear as defects before his sight. Von Reuss frankly admits his perplexity as to whether these oscillating fields properly belong to hysteria or to neurasthenia, but is inclined to define them as an hysterical phenomenon. In his experience he admits that the scotoma was variable, but not so transitory but that it endured between the 8th and the 19th of the same month; but in Koenig's cases the scotomas in the oscillating field were not transitory. He tested but one meridian each day, thus requiring ten days, and then formed his chart picture from these interrupted tests.

He also repeated the tests in each meridian, and found the scotoma spaces and the scotoma free spaces constant; also in Wilbrand's case the condition lasted at least for many days, all this indicating phenomena of enduring character and thus more hysterical than neurasthenic in nature.

Besides concentric contraction we may find as other stigmata in the field the presence of central scotoma, scintillating scotoma (Flimmer skotom), or hemianopsia.

Evans (*Ophthal.*, Feb. 1912) points out that these scotomas possess a certain degree of stability which distinguishes them from similar conditions found in the exhaustion type of neurasthenia. de Schweinitz has observed a case of central scotoma in an hysteric woman that lasted for many weeks, and Charcot reports a case of concentric contraction in an hysteric patient which lasted thirty-eight years.

In very grave cases where the field is contracted almost to the fixation point the constancy of the resulting "tubular" vision has been a subject of disagreement. Schmidt-Rimpler (*Deutsch. Med. Wochen.*, 1892, Nr. 24) and Wollenberg maintain, that as the distance of the patient from the campimeter is increased the size of the

"tubular field" increases in direct proportion, while Greeff and de Schweinitz assert the limits remain constant in size: "Instead of an increase in the width of the field it may remain just as narrow as it was prior to the lengthening of the fixation distance and the same is true if this is still further increased—for example to 2, 3, or 5 meters." (de Schweinitz.)

When associated with anesthesia of the skin the field restriction is usually greater in that field which is on the side of more extensive anesthesia and unilateral restriction, usually appearing on the hemianesthetic side. In unilateral field contraction this may sometimes be caused to disappear in this field and appear in the field of the other eye upon the use of suggestion, or irritation of the skin.

Parinaud makes the remarkably interesting assertion that by puncturing the skin on any part of the body he was able to increase the extent of the visual field, and, in certain cases, able to render it normal thereby.

(B) *Changes in the color field.* Just as the insensibility to white light, either retinal, cortical, or both, manifested by concentric contraction of the field is a dominating expression of hysteria, likewise this insensibility, or diminished sensibility, to color is a frequent attendant symptom and manifests itself in concentric contraction. Dyschromatopsia is not always present and when present is not always found to extend in the usual procession of the color-field outlines. Parinaud affirms that to be assured of "The presence of dyschromatopsia from the contraction of the color-field alone, it is necessary that the latter should be well marked relative to the contracted field for white."

Even though the color-fields retain their usual relationship from the periphery toward the center of blue, yellow, red, green, violet, though somewhat restricted, does not necessarily show the existence of dyschromatopsia, but may be a personal peculiarity of a normal subject, or due to inaccuracies or failure of light, or lack of full color saturation of the test objects. It is in the presence of this so-called "inversion of the color fields," that we find much more convincing evidence of dyschromatopsia.

This phenomenon of inversion expresses itself in a larger field for red than for blue, or in an equality of the fields for red and blue, or in a crossing of the color circles. It is possible to find the field for red not only the largest of the color-fields, but to find it even larger than the field for white—that is, the restricted white field.

It is true that the green field may be found the dominant one, as noted by Binswinger, von Hochwart and Topolanski, as well as Pan-

sier, and the red much diminished, but it is nevertheless a cardinal fact in hysteria that the perception of dull colors weakens first, and that the perception of red color is often, so far as the other colors are concerned, an exaggerated one. It is of interest in this connection to remember that the red field in tabetic and alcoholic amblyopia is often the first to be affected.

Usually the color-fields disappear toward the fixation point in the order of green, blue, red. When, with concentric contraction, we find color scotoma, an exception to this order is found, and this latter condition of central color scotoma with peripheral color-field restriction gives us, as pointed out by Parinaud (Norris and Oliver, *System of Diseases of the Eye*, Vol. 4, p. 736) an intermediary zone lying between the central circle and a peripheral zone. Throughout it is to be found that there is a diminished ability to see color. Small color objects are poorly, or incorrectly, perceived so that blue may appear as gray, red as brown. When, however, the test object used is very bright, as a small electric light, full limits are found on all the meridians. If the patient fixes intently for some time the peripheral field becomes foggy, and more so on the poorer illuminated side, this being a manifestation of retinal tire. If the functional disorder is of recent onset there is from day to day a change in the field to be observed.

Williams (*Lancet, Aug.* 19, 1911) says "It was formerly supposed that inversion of the visual fields for blue and red was pathognomonic of hysteria, especially when a contraction of the field for form was present in addition. Not every one is yet acquainted with the work of Babinski, which has clearly shown that perimetric examination of hysterical patients as ordinarily conducted are relevant of suggestions, and that these very often influence the patient so that the findings are not reliable except as indices of suggestibility."

Williams gives the following method for measuring color inversion or interlacement. He says "To measure this inversion or interlacement of the color-fields accurately a perimeter is, of course, required, but I have found that the inversion may be ascertained roughly by the following method: The patient sits with his back (face) to a good light looking fixedly at a point in the distance. He is directed to signal as soon as he sees any movement. The visual field is then approached by the observer, and one holds alongside and parallel two objects colored of an intense pure bright-red and blue respectively. After the patient signals he is asked to signal again, as soon as he perceives any color, while the center of the field is very slowly approached. The observer then stops the movement and asks what color

is seen. To corroborate, the movement is then continued until the other color is seen. In normal persons blue is always seen before red, and if the technic be carefully performed the test is quite a reliable one, and is a useful addition to clinical methods.''

(C) *The field in neurasthenia.* Here the different peculiarities of the different fields are but manifestations of the phenomena of retinal neuresthenia, that is, retinal tire or fatigue. In such tests, made to elicit the phenomena of retinal exhaustion, we observe that the field of vision becomes more easily exhausted on the temporal side; and the nearer the tests made, involving the central zone of the field, and especially the nearer to the fixation point, the least variations occur, indicating less susceptibility of these areas to exhaustion. It is then to be observed that the peripheral zones are the weaker in their capacity to resist fatigue. This subnormal capacity to retain luminous impressions when slight exactions are made on it are the result of diminished excitability in the visual substances in the retina (Hering), or to cortical exhaustion (Charcot, Leber), as compared with proper physiological conditions existing in normal subjects. Hering explains this by assuming that in normal subjects the material used, during the action of light upon the retinal substances, is spontaneously and continuously supplied, so that the retinal excitability remains at one stage; the absence of this activity causes diminished retinal excitability inducing the symptoms of retinal fatigue. If the cause is inherent in the retina this explanation will suffice, but it is probably found in certain cases elsewhere.

In making such tests in neurasthenics the same degree of stimulation must be employed for the second, as was employed for the first, i. e., the same size test object and the same degree of illumination, and, to the fullest extent, the same time element introduced, and no attempt should be made when the patient is already exhausted.

von Reuss asserts that while we behold in hysteria a functional suppression of certain retinal portions, as evidenced in the field, in neurasthenia, we are dealing with fatigue, or slight weariness of the optical apparatus, which comes to light in the field investigation itself. He says: ''The neurasthenic fields are fatigue fields, their stamp is that of change and evasiveness.''

The following forms of change in the visual field have been described by different writers as properly relating to neurasthenia.

(1) *Concentric contraction of the visual field.* Concentric contraction occurs as in hysteria, and while like it in form has a less enduring character, constantly changing even during the examination, while in hysteria, as already described, this contraction remains until re-

covery occurs; thus enduring contraction is not a characteristic of the visual field in neurasthenia. The contraction may be a complete or a partial one. The fields at the beginning of the examination may be normal, and the contraction may first occur in the course of examination, and for this reason Koenig designates it "examination contraction." In hysteria the color-fields may, one or more, entirely disappear, while in neurasthenia this is rarely so, the color fields, while diminished in certain cases, retain their usual relationship to each other. Wilbrand has, however, reported temporary complete loss of the color-fields in neurasthenia.

Schiele (*Arch. f. Augenh.*, XVI, 1886, p. 145) fatigued systematically the meridian in one-half of the visual field, passing from periphery to the fixation point (Schiele's radial centripetal method), and found in the eye not under examination, and which had been covered, a corresponding contraction to the contracted area of the field under examination. On this phenomenon he based a theory that each portion of the retina of one eye is related to its homonymous portion of the other, and thus the fatigue was manifestly a cortical one. This idea has been rejected since we find that when one sector of the retina is fatigued other portions of the same retina undergo fatigue, and show in this order in the field.

(2) *Förster's shifting or displacement type.* (Fig. 30.) This field was first described by Förster at the Ophthalmological Congress at Heidelberg in 1877 as a peculiar phenomenon that occurred with anesthesia retinæ. The feature of this field is that we obtain from the same eye two entirely different fields.

The first field results from a "centripetal" movement of the test object, the second field obtains from a "centrifugal" movement of the same. For example, in the first case one brings the test object into the field from the temporal side, and records the first perception of it on that meridian. The object is carried across the field and into the nasal field, and when lost here the point is again noted. After a few minutes rest another meridian is taken until nine or ten are so tested, i.e., always from the temporal across toward the nasal side. These connected points give us a field—the first field. The test is continued, but we now start on the nasal side and cross toward the temporal, getting on each meridian a mark of entrance and one of exit. These connected make the second field, which is designated the "control examination." It will be observed that after these points of the second field are connected up they make two unlike, or "shifting," visual fields, and it will be further noted that the total extent of the two fields gives us a completed visual field reaching, or approaching,

the normal limits. It will be noted, as the crux of this phenomenon described, that the side from which the test object enters the field is nearer the normal field limit than where it takes its exit on each meridian, so that when we enter at the temporal (entrance) side, we get there less restriction than on the nasal (exit) side, which is restricted to a marked degree, and when we bring the object from the nasal (entrance) side we get less restriction than on the temporal (exit) side.

Wilbrand (*Arch. f. Aug.*, XII, 1883), Koenig (*Arch. f. Aug.*, XXII, 1891), Siemsen (Address, Berlin, 1895), have all reported numerous cases, but the fields are for white only, while Förster in his original investigations found the same phenomena of ''shifting'' in the color-fields.

(3) *Wilbrand's exhaustion type.* To develop this field phenomenon Wilbrand proceeds as follows: He uses only the horizontal meridian of the field and, beginning at the temporal side of this meridian, he carries the object toward the nasal side, and marks with an ''O'' its entrance into the temporal, and with an ''I'' its disappearance from the nasal field. (See Fig. 31.)

The test object starts immediately from ''I'' reversely across the field toward the temporal side being still on the same meridian. The point at which it disappears in the temporal field is marked ''2.'' The object is again brought back toward the nasal side, and the point of its disappearance in the nasal field is marked by the figure ''3.'' This is repeated until the figures outline the portion of the field that resists fatigue. To this latter field—that which resists fatigue—Wilbrand gives the name of the ''minimum field.'' To the field as it evidenced itself at the beginning of the examination Koenig applies the name ''maximum field.'' Wilbrand states that when fatigue is found on one part of the test meridian it is found on all the remaining meridians of that part of the field affected, and that the color fatigue corresponds to the form fatigue, to which latter Koenig dissents. He thinks the color fatigue does not strictly accompany the field for white, and also that it does not exist in the same degree.

(4) *The oscillating field.* (Fig. 33.) As many authorities deem this properly an hysterical field phenomenon, it has been described in detail under the field manifestations of this affection. Koenig, Wilbrand and others, however, report this phenomenon as one to be observed in neurasthenic cases, as well as in hysteria.

(5) *The fatigue spiral field.* This type of ''fatigue field'' in neurasthenia von Reuss (*loc. cit.*) first demonstrated in 1897, and he then considered it simply in the nature of a curiosity, but subsequent and

systematic examination after this time has brought to light many such cases. Straub and Fuchs have both observed this phenomenon, and the former speaks of its use as an "elegant method" to elicit the phenomenon of retinal fatigue. Fuchs observed it in both hysteria and neurasthenia. (See Fig. 32.)

von Reuss used a MacDonald-Hardy perimeter, and always preceded the field test by the examination of the fundus by the ophthalmoscope, and the tests for central visual acuity. This is not only necessary to complete the record, but has the advantage that it induces a certain amount of fatigue before the visual field tests are begun.

In the usual field examination, and in a normal eye, we know that when the points of entrance of the test object into the field periphery are connected we outline thereby a normal field.

On repetition of this test we get practically the same result. In the "fatigue spiral" field, however, this point lies within the point marking the first field on the same meridian—for example on the horizontal—and this interior position of the successive points of the second test is found on all the subsequent meridians taken. On the third fatigue test the points marking it are again found within those marking the second test, and so on throughout all subsequent tests until they no longer show a difference as they are carried toward the fixation point.

By the connection of these points marking each separate test one obtains the so called "spiral" which ends in a closed line. The term "watch spring" (Uhrfeder) has been applied to this field.

It is, of course, understood that the visual field does not possess in fact the form of a spiral, and that this spiral is merely the evidence of the gradual concentric contraction that results from fatigue.

(6) *The recuperative extension field.* von Reuss remarks that just as in neurasthenia a narrowing of the field results from fatigue, it is to be observed that such a field may again enlarge to nearer its normal limits if allowed to rest and thus recuperate itself. The extent to which the fatigue field may again approach the normal depends naturally upon the degree of the fatigue as well as upon the time allowed for recuperation. It is to be noted also that emotions, and the exercise of will-power, may affect the enlargement.

Wilbrand has studied this recuperation after exhaustion by allowing the patient to remain in a darkened room for a considerable period of time, and using illuminated color-test objects. von Reuss has pointed out in this regard that the tests are so complicated and time-demanding as to render them impractical in ordinary clinical application.

Traumatic neurosis and "the mixed fields." von Reuss states that just as functional and organic diseases of the nervous system

may be associated and interwoven, as observed in traumatic neurosis, so are the fields in such cases of traumatic neurosis often found to be a combination of both hysterical and neurasthenic phenomena.

These mixed forms of visual fields are, according to this writer, fields that demand great care in differentiating. A concentric contraction of the field that undergoes narrowing during the examination is properly designated a field of mixed form, being originally an hysterical characteristic, with a neurasthenic characteristic later superadded, as shown by the fatigue contraction appearing with the more enduring hysterical contraction found at the beginning of the test. This original peripheral contraction can only with certainty be accepted as such when it appears instantly at the beginning of the examination.

Wolfberg (*Arch. of Oph.*, 1904) thinks that in traumatic neuroses we have an abnormal fatigue not of the retina alone but of the entire neuroptic apparatus, including the cerebral centers. The fatigue exists, as shown by quantitative color tests, in the macula, but is also evidenced by spiral field contraction. That any very different complex of symptoms is to be ascribed to cases of traumatic neuroses is surely in great doubt, Bartels (*Zeitsch. f. Aug.*, 1907) going so far as to state that the symptom found in a case of hysteria depends largely on the mental attitude of the surgeon. He who expects to find concentric contraction will find it, and *vice versa.* He thinks the size of the field of no value, but that the investigator can cause it to vary by suggestion argues for hysteria. This view in its entirety is not to be seriously taken, in the light of so much positive knowledge we now possess of the visual field in the different neuroses.

As being stigmata of traumatic hysteria and neurasthenia, von Reuss presents certain odd types of fields; ''the crown of thorns'' field, from crossing and recrossing of lines; the ''abortive spiral'' field, where the constriction does not show after one turn; the ''falling spiral'' where the field rapidly terminates at zero. According to Schmidt-Rimpler the tendency now is to use the terms traumatic hysteria and traumatic neurasthenia, rather than the general term traumatic neuroses. de Schweinitz quotes Oppenheim as saying, that, in so far as the visual fields are concerned those of accident neuroses are practically identical with those of neurasthenia and hysteria. Visual field changes occurring in accident neuroses are not to be confounded with changes in the fields due to evident injury of the eyeball or orbit.

Berlin (*Klin. Monatsbl.*, XI, p. 42, 1873) writing on the latter class of cases, and especially upon cases of concussion of the eyeball, divides them into two classes—First: Cases of which central vision is mod-

erately impaired while the peripheral fields are intact. He ascribes this to a regular astigmatism of the lens. Second: Cases of direct injury showing whitish opacity of the retina at some part. Here the fields may show blurred areas or actual scotoma for white. The visual field disturbances from orbital fracture arise from changes in the optic nerve itself. The writer has shown that such fractures were more common than usually thought.

According to Noyes (*Diseases of the Eye*) traumatic amblyopia with field changes may occur through a great variety of injuries of the skull and brain to which no clew can be found, but in which some disorganization of tissue undoubtedly has occurred to structures concerned with vision. Thus under accident neuroses we find first:—fields that represent true hysteria or neurasthenic features connected with cases in which there may be no actual disorganization of tissue of the neuroptic apparatus, but representing a psychic, hysteric or neurasthenic element induced by the accident; second:—fields that in the eye itself, or in other parts of same apparatus, represent some demonstrable or non-demonstrable lesion.

Concussion of the spinal cord may cause loss of sight. Noyes (*loc. cit.*) reports such a case with central vision of 20/100, and visual field contraction to a space whose angles were less than 30°. Extreme hyperemia of both discs was present. The outcome of the case was unknown. Boland (*Boston Med. and Surg. Journal,* Nov., 1887) reports colored vision, contracted fields, and monocular diplopia in a case of spinal concussion. In these cases the fields remained contracted.

Pansier, Koenigshofer, Heidenheim, Novavchsik and others have written on this subject of the field of vision in hypnosis. The latter (*Neurolog. Central.*, 1899) demonstrated in an hypnotic subject that the fields varied according to suggestion.

Epilepsy. Ranging from the statements of Pinchon (*L'Encephale,* 1888, p. 139) that he found retraction of the fields in 30 per cent. of the cases of epilepsy, to those of Heitier (*Thése de Paris*, 1886) who found in an examination of 87 epileptics permanent contraction of the fields in only 3, we have a series of results reported by different observers which vary almost confusingly.

Pinchon, as stated, found contraction in 30 per cent. of the cases he examined, and his conclusions about the visual field in this disease are as follows:

(1) In a third of the cases there is a slight concentric contraction of the field more marked for red than for white and green, and in

one-sixth of the cases the contraction is very pronounced, but never as marked as in hysteria.

(2) There is never inversion of the color-fields as in hysteria.

(3) There is never a central scotoma, but very often there are peripheral scotomas.

(4) There is never hemianopia.

(5) Irregularity is a constant feature.

These pronounced views, and their somewhat mathematical results as given by Pinchon, it seems should be accepted carefully, and the writer is much in doubt as to their positive value as indicating the frequency of field involvement in epilepsy. In view of the cases of epilepsy examined immediately after the attack, and in many cases examined between attacks, he has found among the latter class only slight concentric contraction, which may have been physiological or due to other causes.

Parinaud (Norris and Oliver's *System*, Vol. IV, p. 763) asserts that contraction of the fields is not infrequently observed in epilepsy, but believes that many of the fields reported as contraction from epilepsy are in truth contractions from associated hysteria. In support of this view Heitier (*loc. cit.*) in an examination of 87 epileptics in the service of Charcot, found permanent contraction of the fields "not due to any appreciable cause but epilepsy" in only three.

Oppenheim and Thomsen (*Arch. f. Psych. u. Nerven*, 1884) found contraction in one-third of 94 patients examined. Such variations in results obtained lessen, as pointed out by Parinaud, the value of perimetric results in the differential diagnosis of hysteria and epilepsy. Fèrrè (*Révue de Medicine*, 1880) found contraction of the visual fields in eighteen subjects so examined immediately after the attack and states that all epileptic manifestations associated with loss of consciousness are invariably followed by amblyopia. This temporary amblyopia, which may rapidly disappear when there is but one attack, may persist much longer if the attacks are repeated. In this connection Parinaud (*loc. cit.*) states that he has seen patients at the Salpetriere in whom this amblyopia has persisted for twenty-four hours after an attack.

Temporal or slight amaurosis—a visual aura—unaccompanied by a convulsive attack may exist as a true epileptic manifestation. Fèrrè states that hemianopia probably only exists in cases of symptomatic epilepsy. He believes that the amblyopia following an epileptic seizure is characterized by a reduction of central visual acuity as well as changes in the field for form and color.

Parinaud states until the contrary is proven that the amblyopia

following the attacks is not accompanied by dyschromatopsia, or inversion of the color-fields.

Rodiet, Pansier and Cans (*Recueil d'Ophtal.*, March-April, 1908) found that the disturbances of the field may take the form of retraction, scotoma, and ophthalmic migraine, and also hemianopsia. Retraction of the field is irregular in form, often showing peripheral notchings which are not generally symmetrical. The retraction is more marked immediately after the attack than some hours later, and in the period between attacks.

Parisotti (*Bull. de l'Académie de Rome*, Jan., 1892) found vertical retraction but concluded that it was of no diagnostic significance since it occurs in hysteria more frequently than in epilepsy.

Parinaud states "The existence of narrowing of the visual field in epilepsy makes it all the more necessary to base an opinion, not upon that sign alone, but upon the presence or absence of all the symptoms described as characterizing hysteria—a picture which epilepsy would certainly not present." Here may properly be mentioned those interesting cases designated reflex amblyopia and without ophthalmoscopic changes. The reflex irritation may proceed from the teeth, stomach, ovaries, uterus; and Parinaud (*Soc. de Paris*, June, 1889) reported a case presenting all the characteristics of the hysterical field in which the symptoms disappeared after evacuation of a tape-worm.

The value of the fatigue fields in the differential diagnosis of functional neuroses. It cannot be said of any of the functional conditions described that it presents field changes that are so positively diagnostic of it as to exclude to a marked degree of certainty all other of the functional or traumatic neuroses.

In hysteria concentric limitation of the field, even somewhat enduring in type, cannot be held as an exclusively characteristic feature. It is assuredly a symptom of great practical importance, but is not peculiar to hysteria. Here Parinaud places great stress on the value of testing not only the central visual acuity, but especially of establishing the presence of those anomalies of accommodation which have already been described elsewhere in this article. It is to be remembered that concentric contraction is to be found in certain cases of cerebral tumor without neuritis, with intracranial pressure arising from its several causes, and, as observed, in epilepsy.

However, if one holds before himself the accumulated experience of writers worthy of attention, it is not unreasonable to infer, in a given case with certain field manifestations, that we are dealing with an hysterical field; these are that the fields for red, and also other colors,

are larger than the field for white; dyschromatopsia, as shown by the inversion of the color fields; spasm of the accommodation; tonic blepharospasm. We may not expect all of these symptoms, but if some are present with concentric contraction that persists for some time, they strongly point to hysteria. It is to be remembered that we have presented evidence of the persistence for some time of the field retraction existing in epilepsy.

As to this differential value of the visual field in hysteria and neurasthenia, von Reuss (*loc. cit.*) goes so far as to state that "All constant narrowings of the visual field are of hysterical natures, all that is variable in the field of vision belongs to neurasthenia." (*Das Gesichtsfeld bei Functionellen Nervenleiden.*)

The fatigue field, while a distinct feature in neurasthenia, is not an exclusive and determining symptom, as Peters and Voges show that it is not confined to nervous individuals, but may as well be found in healthy persons.

Amidst this apparent nonconformity of opinion it is reasonable to agree with Arnheim that concentric contraction of the field is of undoubted value in the diagnosis of hysteria and neurasthenia, and further still that the fatigue element, although found in hysteria, is more distinctly a neurasthenic phenomenon, and that it shows itself not only in concentric contraction, but in a certain peculiar functional imbalance and tendency to change, that expresses itself in the many peculiar fields described as "fatigue fields." It is not to be forgotten that many hysterics, neurasthenics and epileptics show no field changes of any kind.

Oppenheim believes that the phenomenon of accident neuroses, as shown in the field, much resemble, or are identical with, neurasthenia, hysteria, and hypochondrias. Disturbance of the color-sense is more frequent in hysteria than in neurasthenia, and if present in the latter rarely manifests itself as an inversion of the color circles.

Wolffberg (*Arch. of Ophthal.*, Vol. XXXIII, 1904) regards slight fatigue of the macular region as a symptom of traumatic neuroses not less important than the change in the peripheral vision, and that there is a relationship between the two. As regards the nature of the fatigue causing these phenomena the view of Hering (*loc. cit.*) has already been presented.

Wilbrand thinks that the field contraction is due to changed conditions of metabolism in the external retinal layers. Charcot and Leber think the field is the expression of cortical fatigue, while Sims thinks the phenomenon is referable to a psychical basis. Schmidt-

Rimpler considers the phenomenon of field fatigue one that is brought about by lack of concentration and of inattention.

Malingering of visual field defects. The attitude of the malingerer is one of negation and disavowal, and the continuation of this attitude to the point of assurance that he has simulated to a sufficient degree leads to marked departure from the normal in the fields obtained in such cases.

The deception usually produces, for this reason, a concentric contraction of marked degree in the field without scotoma or sector-like defects, since the simulation of these would be difficult, even if one were in possession of special knowledge regarding these defects.

Simulation of visual field changes are exceedingly difficult, and suggestion from the examiner to the examinee of what is to be expected, or what is not to be expected of him, often leads to quick confusion. For instance in a case of this kind the malingerer was informed that in this condition red was always observed as green, and *vice versa.* He accepted the statement as truth, and answered accordingly, insisting that the red object was green, and *vice versa,* when they first presented themselves in the field. Repetition of the examination on different days commonly leads to very different degrees of contraction since remembrance of his former test in all meridians is quite impossible. The simulation of defect in central visual acuity is not so difficult, for here the patient may quite consistently upon succeeding days give consistent answers.

Wilbrand (Norris and Oliver's *System,* Vol. 2, p. 314) says "The proof of simulation can be obtained from the relation of the size of the visual field to central acuteness of vision." He further states that with a very low degree of admitted visual acuity, the least to be looked for in the field is a central color scotoma, and that the absence of this central color scotoma leads to detection of the fraud. So distinguished an authority must be accepted with great respect, but in the few cases examined by the writer he believes that, except in noticeable degrees of myopia, there is no dependable ratio between central visual acuity and the peripheral field limits, therefore it is not impossible that a patient in malingering could offer a very low degree of central visual acuity with or without concentric contraction, and yet without the presence of scotoma of any kind.

The writer has found, as stated, suggestion to the patient most valuable and the patient may be greatly confused by stating what he will or will not see; for example, a very effective suggestion is to state that the test object does not disappear in the condition he claims to be afflicted with. If, after this assurance he states that it does so dis-

appear in the region of the blind spot, one may give some consideration to his report regarding other portions of the field, whereas on the other hand if he acts upon the suggestion and insists that he sees the test object throughout the entire area of Mariotte the inference is that his answers are unworthy of belief.

Where low visual acuity has been simulated patients will sometimes state that they do not see the test object at the fixation point, while it is admittedly seen exterior to this on other meridians.

If the marked concentric contraction is real the relation of the orientation of the patient to this defect may be considered with advantage.

Another common and valuable method is to take the field at different distances from the eye, and compare the constancy of the successive fields so obtained.

Wilbrand's method. Wilbrand (Norris and Oliver's *System of the Diseases of the Eye*, p. 313) introduced the following method to detect malingering. "To the middle of the upper margin of the perimeter is to be fastened a black linen thread three times as long as the radius of the perimeter, and on this thread is to be hung a white ball having a diameter of fifteen millimetres. This ball is placed at the end of a long black iron rod. By this means the ball can be carried in all directions of the field of vision at similar distances. If the circle of the perimeter is placed in the vertical meridian, the examinee made to fix his eye, and the white ball placed at the full extent of the thread and carried from the periphery towards the fixation point in the horizontal meridian, the ball will be arrested when it reaches the spot where the patient observes it. The circle of the perimeter is then to be brought to the ball and the corresponding parallel circle read off. In this way the greater portion of the field of vision can be determined. Care must be taken to have the circle of the perimeter perpendicular to the axis of the meridian that is examined, so that the simulator may have no point by which he can mentally measure the position of the object in space. It is necessary that the perimeter be so placed that a black wall in the shape of a half-cylinder shall surround the test-object so that the simulator cannot by indirect vision see anything but the perimeter upon a black surface.

"The size of the field is first measured; after a calculated period of time for recuperation, the field is retaken with an ordinary five-millimetre-square white object. Generally the simulator is found to possess a much larger field when examined by the thread apparatus than when he is examined by the ordinary method."

Wilbrand (*loc. cit.*) also states "When the color-limits are studied

with the perimeter, the boundaries for color of the least light intensity should be taken first, beginning with green, then red, and lastly blue. During the examination the simulator should not be asked to state when he recognizes the color of the examining object, but should always be requested to state when he recognizes the surface."

Comparison of the two fields where no visible ophthalmoscopic changes are to be found is sometimes of value.

Koenig does not think it possible for a patient to continuously deceive a skillful examiner in the successful simulation of concentric restriction of the fields, especially when such false restrictions are designated of low degree. Concentric contraction of high degree may be simulated by the comparison of the fields taken from day to day and will expose the deception.

Koenig has devised a method in which he tests different meridians at random, and at some considerable distance apart instead of taking each meridian in succession, as is usually the practice.

von Reuss thinks the fatigue spiral is a conclusive proof that the case is not malingering.

The use of different sized test objects unbeknown to the patient is an excellent practice in such cases.

Schmidt-Rimpler method. This method described by Wilbrand consists in fixing the test object at its limit of recognition on the arc. The prism of 30° is then placed before the other eye, and the patient directed to fix with the eye behind the prism. The prism is so held that the test object falls on the area said to be blind. The fixation point being seen double the simulator is tempted to give a correct answer that he sees the test object in the perimeter at the same time that he sees the test object through the prism, which also proves the fraud.

Baudy, Wilbrand and Sänger and Bichellone (*Annales d' Oculistique*, CXXIX, 1903) have written on this subject, the investigations of the latter being particularly thorough.

THE VISUAL FIELD IN SYSTEMIC DISEASES.

It will make the understanding of visual field changes occurring in brain and spinal cord disease easier if we remember that embryologically and anatomically the optic nerve is not a nerve as are the other peripheral nerves of special sense, but is, together with the optic tract, really a part of the brain even so far as its retrobulbar and most peripheral extensions, including its cup-like expansion the retina. Here, in disease like tabes and multiple sclerosis, the processes are

simply an extension into a like stem; if the posterior column, for example, degenerate, the optic nerve participates as part of the unit.

Tabes. Although, as shown by Uhthoff (*Arch. für Psych. und Nervenkrank.*, Vol. XXI, p. 55) there is a remarkable lack of relationship, or proportion, between the ophthalmoscopic findings the visual state and the pathological condition of the optic nerve, it is true, nevertheless, that the visual field symptoms in tabes are of very great diagnostic importance, and with the exception of glaucoma—whose field it sometimes approaches in appearance—are probably more distinctive of this condition than are the field changes occurring in any other organic nerve disease.

Earlier writers dwelt upon concentric contraction as a feature of this disease, but the studies of Uhthoff, Galezowski, Lobel, Babinski, Chaillons, Polak, Rönne, and especially of Fuchs, show that the distinguishing feature of this disease is a central scotoma of a distinctive and interesting character. While Babinski and Chaillons found (*Recueil d'Ophtal.*, 1907, p. 89) central scotoma a rare occurrence, and considered it an evidence of intercurrent toxic retrobulbar neuritis, they expressed the view that, when found, it is a detached sector defect involving the point of fixation, while a large part of the periphery of the field is retained. Polak found full peripheral fields and relative scotoma for red extending to the blind spot. Galezowski and Lobel (*Recueil d'Ophtal.*, April, 1906) estimated the appearance of central scotoma as from 2 per cent. to 4 per cent. in tabetic atrophy.

Rönne (*Ophthal.*, Nov., 1911) found the fields in tabes often presenting changes not unlike those of glaucoma with a scotoma limited to a horizontal meridian. In the splendid contribution of Fuchs (*Trans. Am. Ophthal. Soc.*, 1911) we find the field changes in this disease clearly described.

The writer thinks that Uhthoff's estimate of 2 per cent. of the cases in tabetic atrophy as showing scotoma is too low. He does not estimate the percentage, but in the discussion following his paper states 30 cases as the full number of central scotomas seen among many cases of tabetic atrophy, which certainly amounted to many hundreds; he believes the scotoma is directly related to the tabetic atrophy as a sequel, and not as a complication of a simultaneous retrobulbar neuritis. The central scotoma is nearly always bilateral, although unilateral cases are reported.

At onset the scotoma is round, exactly central, and associated with involvement of the blind spot of Mariotte. It gradually extends toward the blind spot and assumes the form of a horizontal ellipse. The character of the scotoma is truly interesting. It is a relatively

blind area for color within which area—if the test be made with great care with small test objects, and at a distance of one meter (Bjerrum's method)—we find small spots of absolute blindness. The blind spot is one of these small absolute scotomas, but around the center of the relative scotoma may be found a small absolute and incomplete—usually—ring scotoma. Later the entire relative scotoma becomes absolute.

Together with the formation of this ring scotoma there is a slight concentric contraction, greater for colors than for white, which later may show the limits for white considerably wider and the color fields entirely lost. Later the peripheral contraction becomes irregular, showing indentation on one side gradually invading the field until it joins the already greatly enlarged central scotoma, leaving only an eccentric field. Central acuity of vision depends upon the condition of the scotoma if dense vision is naturally bad. In most cases there is a relationship in degree between the scotomatous changes and the peripheral field changes.

As compared to the field conditions just described we may speak of those occurring in toxic amblyopia. In the latter where central scotoma is most common we find that the periphery of the field almost always remains normal—some writers state always—as well as the perception for color outside of the scotomatous area. This early loss of the whole of the color-fields, and its progressive character, indicates tabes. In toxic amblyopia the disc looks normal at the onset but in tabes is pale, and this later spreads from the temporal to the nasal half.

Fuchs states that it is more difficult to distinguish tabetic scotoma from that due to syphilitic retrobulbar neuritis, since in both may exist abolition of reflexes and the Argyll-Robertson pupil. As indicating the latter condition he thinks there are but two symptoms to assist us: First—The results of proper antisyphilitic treatment, and second—that the disc pallor in scotoma from syphilis is only likely to develop at a late stage. He does not deny the existence of syphilitic retrobulbar neuritis, but thinks that the scotoma is an integral part of the tabetic process nevertheless.

Some locate the lesion in the ganglion layer of the retina and others in the optic nerve; the early involvement of the blind spot, and the tendency of the scotoma to proceed toward it, favor the latter view.

Bitemporal hemianopia occurs in tabes and Fuchs states, "We must assume that the tabetic degeneration, as a rule situated in the optic nerve, may exceptionally locate itself farther back in the chiasma, so according to my belief bitemporal hemianopia is in most cases of tabes

to be considered not as an accidental complication due to syphilitic inflammation, but as a genuine tabetic affection."

These cases of bitemporal hemianopia are exceedingly rare and, excepting this condition, is only found in cases of pituitary tumor causing pressure on the underside of the chiasm, or in syphilitic inflammation in the same place.

In these cases the preserved nasal fields are markedly contracted, especially for color, which is rapidly lost, with symmetrical and gradual loss of the form-field and with pallor of the discs showing from the onset of the affection. This complex of symptoms, so characteristic of gray degeneration in the optic nerves, causes Fuchs to think we are here, in such rare cases of bitemporal hemianopsia, dealing with the same process.

de Schweinitz refers (see *Trans. Am. Med. Ass'n,* 1911) to investigations made in France in which the subjects of central scotomas were always found to be users of alcohol and tobacco and that with these agents eliminated scotomas do not occur in tabetic atrophy. This, it is to be understood, is simply a reference and does not express de Schweinitz's views. Fuchs further states that in these cases stopping of the tobacco and alcohol should bring improvement, which it did not do in his cases of tabes with scotoma. Central scotoma in tabes, as in toxic amblyopia, is usually bitemporal. The central scotoma occurring in accessory nasal sinus disease is often accompanied by symptoms referable to the sinuses, and MacWinnie found isolated scotoma in such cases occurring in the intermediate zone of the field. Here we usually find the affection unilateral with fundus changes apparent, or differing entirely from those to be observed in tabes.

Other conditions causing central scotoma are multiple sclerosis, acute myelitis, acute anemia from general hemorrhage, and cranial injury.

In connection with the described visual field changes the associated pupillary reflexes lend some assistance. The Argyll Robertson pupillary reflex is generally, although not always, present. Barnwell states (letter to Swanzy), "In the vast majority of instances in which I have found the Argyll Robertson pupil present the case has been one of locomotor ataxia, or of general paralysis of the insane."

Mott regards restriction of the field and optic atrophy as the early signs of tabes.

Halbau reports a case in which the temporal field of the right eye was markedly limited, especially for red. Gowers and Gabrielides have also reported double temporal hemianopsia.

Benedict was probably the first to notice color changes in the field in tabetics.

W. Dodd reports a curious case in which the patient saw everything a bright emerald-green color. In this emerald field he, at times, saw rose-colored spots. The intensity of these colors increased upon fatigue. After six or seven years the vision in the right eye was 2/60, and in the left eye 1/60.

Langenbeck (*Klin. Monatsbl. f. Augenh.*, Aug., 1912) in a study of the visual fields of 130 tabetics comes to the following conclusions:

(1) There is no absolute typical form of visual field in tabes.

(2) The defects most commonly observed are peripheral defects, confusion of the color-fields, and early loss of color perception throughout the field. Less often is found partial defects with well preserved function in the parts remaining.

(3) The rarer cases with the central defect require repeated examination in order to uncover a possible retrobulbar complication.

(4) Hemianopic visual fields are not found in uncomplicated tabetic optic atrophy.

Disseminated sclerosis. Uhthoff (*loc. cit.*) found that in multiple sclerosis there could exist marked disease of the optic nerve trunk without ophthalmoscopic or visual field changes. It must be considered questionable, however, if this would be frequently true if the tests were to be made properly under the exacting Bjerrum test. Although Harris (*Brain*, 1897) states that he has seen hemianopsia in disseminated sclerosis, the prevailing opinion is that it does not occur, and that the occurrence of the Argyll Robertson pupil is rare. (Swanzy.)

According to Swanzy the common visual field defects in this condition are amblyopia with central color scotoma, irregular peripheral field defects—sometimes only for color with or without scotoma—and in some cases regular concentric contraction. Complete loss of sight in this disease is rare. Disseminated or multiple sclerosis is a condition rich in eye symptoms, but it is our province simply to relate those connected with the field. Optic atrophy occurs in about 50 per cent. of the cases and paralysis of the ocular muscles is frequent, as is also nystagmus.

W. Hirsch in Posey and Spiller's work states that "There is no homogeneous narrowing as in case of tabes, but in most, irregular constriction of the peripheral line. There may be central scotoma or a combination of this with an irregular narrowing of the field. In a few cases an annular scotoma has been found, and in other rare instances small parts of the periphery were alone preserved while the

function of all the rest of the nerve had been lost. Sometimes there is a central scotoma only for colors, or in some cases a general achromatopsia."

It must by this time strongly appeal to the observer how very important the picture of central scotoma is to be held, for as the great sign of retrobulbar neuritis it may signify that a toxic agent has attacked the papillo-macular bundle, or that it is the precursor of a disseminated or multiple sclerosis. As a precursory symptom of the latter disease it may show itself years before the disease.

Marx (*Arch. f. Augenheil.*, July, 1909) says that it is a symptom which appears in from 30 per cent. to 40 per cent. of the cases in from some months to seven years before the manifest and certain onset of the disease itself.

Kamperstein (*Arch. of Ophthal.*, May, 1909) in 37 cases found central scotoma absolute in five and relative in five, central scotoma with peripheral contraction in three. Green-blindness in one case only.

The field changes in multiple neuritis are not so regular or uniform as in tabes. In the latter condition the disease is throughout more symmetrical and uniform, almost always showing a bitemporal atrophy of the nerve heads and bilateral field involvement.

General hemorrhage, anemia and chlorosis. General hemorrhage may induce concentric contraction so marked that it approaches close to the fixation point. Carlini (*La Clinica Oculistica,* Feb., 1906) reported complete amaurosis with subsequent affection of the fields after severe hemorrhage. The case was exsanguinated but after transfusion rapidly recovered. There was complete blindness and also complete absence of ophthalmoscopic changes. Vision began to return on the fourth day. The final status of vision was 5/50, and a sector-like defect in the lower side of the left fields, that is, an imperfect left hemianopsia.

Carlini in speaking of these cases of field defects following hemorrhage arranges them in three groups: First—Where at no time are found ophthalmoscopic changes. Second—In a somewhat larger group, where there is at once, or later, a decided pallor. Third—A group where edema of the discs along the retinal vessels occur that may later show true papillo-retinitis.

In 1860 von Graefe suggested in explanation of these field changes a hemorrhage into the nerve sheath, or interstitially among its fibers. This view was soon found not to be sound since it failed to explain those cases in which the field defects occurred days or weeks after the hemorrhage.

Samelsohn propounded a theory that "In the moment of the loss of blood the intra-cranial contents are reduced and a vacuum would result were it not that the lymph and cerebro-spinal fluid are attracted. Later when the blood is resupplied to the cranial cavity the lymph is again in part driven into the inter-sheath space of the nerve, thus producing a condition closely analogous to choked disc." This, as pointed out by Carlini, is not supported by the cases with no visibly ophthalmoscopic changes. Spasmodic contraction of the arteries may explain, but is not likely to be present in extreme hemorrhage.

Carlini (*loc. cit.*) presents the theory that the lesion is cortical, and is produced by edema naturally following a large hemorrhage. In support of this he states "We find in a considerable portion of the cases a more or less complete hemianopsia." To further sustain this view he reminds us that in his case the pupillary reactions were retained from the first, indicating a central rather than a peripheral lesion. The convulsive seizures present also accord with this view.

Bleeding, not excessive, is not attended, as a rule, by field changes.

In a case of hematemesis recorded by J. J. Evans (*Birmingham Med. Review*, Sept., 1899) there was loss of practically all of the lower half of each field and marked contraction of the upper part. In another case reported by the same writer the entire left field was lost excepting a small arc-like area from the 10° to the 30° circles in the upper temporal quadrant.

Moore (*Trans. Ophthal. Soc. U. K.*, 1911) reported a somewhat similar case following uterine hemorrhage, but there was concentric contraction of the left field.

Concentric contraction has been reported in anemia, and F. Richardson Cross (*Bristol Med.-Chirurg. Journal*, March, 1911) has reported a positive central scotoma for white, and field contraction for red, following retrobulbar neuritis dependant upon anemia. It is well known clinically that hemorrhage from the stomach, bowels and uterus may cause entire obliteration of the visual field. Michel (*Festschrift zur Fredrich Horner,* 1881) has observed changes in the field in connection with aneurismal dilation of the carotids on both sides.

Frankel, Uhthoff and Elschnig have proved that thrombotic obstruction of the ophthalmic artery, while having but little effect on the intra-ocular circulation, may induce marked changes in the fields. Changes in the retinal circulation have been elsewhere considered under the field changes due to intra-ocular disease.

Temporary monocular amblyopia may possibly be due to embolism in the optic nerve. Hansell reports such a case, the subject of chronic

endocarditis, in which the vision of the left eye suddenly became practically lost. After five days vision was restored to full acuity. The ophthalmoscopic findings were negative. The diagnosis was reached by exclusion.

In the acute papilledema associated with chlorosis we may find concentric contraction.

Posey in the *American Ophthalmological Soc. Trans.* of 1909 reports a case of chlorosis in which the fields in both eyes were concentrically contracted. The left eye was free from scotoma, while the right eye had a large absolute scotoma extending 20° from the fixation point upward and outward. Posey states that in 19 cases of chlorosis examined by him there was no appreciable swelling of the disc, or true neuritis.

Of 50 chlorotic cases examined by Saundby and Ealls in 1882, however, some degree of neuritis was found in 8 per cent. A few cases have been reported where the changes in the fundus were so marked that they were mistaken for the ocular signs of albuminuria or brain tumor.

Posey's case was that of a Jewess complaining of poor vision and general weakness. Her attack had lasted for two months. The vision in the right eye was reduced to fingers at one foot; corrected vision in the left eye was 6/12, and both eyes were the seat of an intense retinitis. The symptoms present made the diagnosis of chlorosis definite, and in the absence of all other symptoms it seemed that the ocular inflammation has been occasioned wholly by anemia. Hirschburg in 1879 was the first to note the optic neuritis in chlorosis. Wilbrand and Sänger assert that a very high intra-ocular pressure is frequently present in patients with anemia, and chlorosis. Cushing and Bordley, of Baltimore, conclude that the alterations of the eye-ground in nephritis are to be attributed in part, if not wholly, to the mechanical effects of increased intra-cranial pressure resulting from cerebral edema.

The orbit and accessory nasal sinuses. (a) *Orbit.* Orbital growths may, by pressure upon the optic nerve and by obstruction of the retinal vessels, bring about changes which may show as defects in the field. Ring (*Ophthal. Record*, 1910) reports orbital fibroma with contraction for both form and color, in one field very marked with slight contraction of the field of the other eye, and some irregularity in the area of the color-fields.

Wood (*Trans. Soc. U. K.*, Vol. XXI, 1901) reports pulsating exophthalmos with central scotoma and contracted fields. Birch-Hirschfeld

found central scotoma with orbital cancer involving the ethmoid which he considered of toxic causation.

Evans (*Ophthal.*, Jan., 1912) speaks of one of his own cases with normal field in a case of compression of the optic nerve from an extra-dural tumor of the optic nerve and refers to a case of Onodi's where sarcoma surrounded the optic nerve and yet the nerve remained histologically normal.

(b) *Sinus.* While it may not be stated that alterations in the field occur with nasal sinus disease, which are absolutely pathognomonic of that condition, it is true that very frequently field changes occur as a direct result of sinus involvement that have great diagnostic significance, and the literature of the last five or six years is quite rich regarding this subject.

Onodi (*The Optic Nerve and Accessory Sinuses of the Nose*) and van der Hoeve (*Arch. of Ophthal.*, Jan., 1911) especially have by their study and investigations enabled us to obtain a clearer understanding of the true relationship between sinus disease and the pathological changes in the orbital portion of the optic nerve, as expressed in more or less characteristic field changes. Briefly these changes in a large measure concern the region of the blind spot, and consist simply in its enlargement in the field, or again to the degree of a peri-papillary or central scotoma, with or without peripheral restriction. van der Hoeve thinks that this is a very early symptom to be found in the disease. Onodi (*loc. cit.*) found that red and green showed the largest scotomas, blue smaller, and white the smallest. This was, at times, reversed for red and green. van der Hoeve thinks this peri-papillary scotoma may exist for a long time as the only field change, and that this sign is positive in the presence of the following visual conditions: first—When the scotoma for colors is much larger than for white; second—When the extent for white and colors is greater than normal; and third—When the size of the scotoma changes in the course of the disease. These signs do not seem of any very great practical value, however, since they may be found in retrobulbar neuritis due to other causes, and enlargement of the blind spot is a very favorable symptom.

de Schweinitz (*Trans. Am. Ophthal. Soc.*, 1910) reports scotomas with or without peripheral contraction in sinus disease, and cites a case in which a slight ring scotoma surrounded the fixation point in the left eye, with a triangular para-central scotoma in the right, which became a large oval central scotoma, and finally improved after continued irrigation of the sinuses.

MacWhinnie thinks the presence of ring scotoma warrants the

assumption of accessory sinus disease even in the absence of manifest signs of that disease, and further than the enlargement of the blind spot with relative para-central scotoma for white appearing with manifest sinus disease, we have a typical visual field, a view Friedenberg (*Ophthal.*, July, 1913) does not concur in.

Congestion of the optic nerve is not always a satisfactory explanation since it is not always observed with these field changes.

In this connection Klein (von Graefe's *Arch. f. Ophthal.*, Bd. LXXV, 1910) found the blind spot enlarged, sometimes for color only, sometimes for both color and white, in sinus disease. He observed great improvement following lavage but only after operation was recovery complete. Plugging of the orifices of the sinuses caused enlargement of the blind spot in those cases where the mucous lining was diseased, but did not change the character of the blind spot in those cases where the mucous membrane was healthy. From this experiment he assumes that intoxication plays a part in disease of the peri-papillary bundle. This writer further found the peripheral fields normal, but with enlarging blind spot, and only slight fundus abnormalities. Evans (*Ophthal.*, Jan., 1912) states that "It is generally found, when patients consult an ophthalmologist, that there are grosser changes in the optic nerve and changes in the peripheral field associated with central scotoma." He has reported a one-sided hemianopia and also a bitemporal hemianopia.

Glegg and Hay have also reported bitemporal hemianopia in ethmoid disease.

There can be no doubt that central scotoma occurs in many cases of sphenoid and ethmoid disease, and Birch-Hirschfeld states that the damage takes place in the papillo-macular bundle. It is to be remembered that the field changes are usually unilateral and not bilateral, as we find in toxic amblyopia.

Watson Williams and Freudenthal have reported cases of permanent loss of vision following curettement of the ethmoid, and also from the Killian operation on the frontal sinus.

As indicating the very great present-day interest in visual field changes in nasal and accessory sinus disease, as well as the remarkable frequency and variety of these changes, the recent very exhaustive investigations of Marbreiter (*Zeitsch. f. Augenh.*, April-May, 1914) of the Hungarian University at Klausenburg, are to be noted. The report is based on 100 cases of empyema. It is certainly excusable in view of the thoroughness shown to consider the cases at some length. She selected only intelligent patients with normal vision and fundi, and excluded, as far as possible, ocular disease not resulting from

nasal trouble; also all ocular affections which could present similar field changes—for example, hysteria, toxic retrobulbar neuritis, pigmentary degeneration, sympathetic ophthalmia, diabetes, multiple sclerosis, myelitis, glaucoma, specific chorio-retinitis, medullated nerve fibers and myopia.

The perimetric examinations began with charting the blind spot, in order to avoid fatigue. This was done with the 5 mm. test object. In 54 cases, otherwise healthy except the empyema, the blind spot was oval, measuring 7° vertically and 4° to 5° horizontally. Its position was usually 1° to 2° under the horizontal and 12° to 15° from the center. When possible the examination was made both before and after the operation. The enlargement was always greater for colors than for white. In many of the empyemas examined changes in the field and nerve were present in spite of normal vision and otherwise normal fundi. She states that enlargement of the blind spot may be the first and only symptom, and that it disappears with sinus recovery, again recurring with relapses. In addition to enlargement of the blind spot, there may be present central scotoma, concentric, temporal, or nasal defects, or ring scotoma. The patients were not always conscious of the visual impairment, especially where the trouble was monocular. The narrowing of the field to 10°, which disappeared after release of the pus, was observed in one case, also a ring scotoma in the region of the equator was observed in connection with an empyema. The writer calls attention to the possible confusion of the form changes and accompanying headache in empyema with the picture of glaucoma. In one case both diseases were actually present. Marbreiter finds that enlargement of the blind spot is much more frequently the first symptom than a central scotoma.

van de Hoeve and Klein consider the presence of enlarged blind spot indicative of empyema of the posterior sinus and that the anterior sinuses were excluded. Marbreiter has found this enlargement many times in disease of the anterior sinus, but found no case like that of van de Hoeve in which the blind spot extended to a central scotoma. In many of the cases the field restriction began to disappear almost immediately after pus evacuation—in one case within an hour. The causative factors in these cases are extension of inflammation, disturbance of circulation, and toxic effect, and those cases in which the scotoma vanishes so quickly after the operation may be ascribed to toxic or circulatory causes; in those cases persisting after pus release the cause was an inflammatory change in the nerve. She ascribes the crescent-shaped enlargement of the blind spot with its concavity toward the center as probably due to circulatory disturbance. The

scattered island defects found rather frequently are also ascribed to this cause; and the field periphery limitation ascribed to both circulatory and toxic causes. Of the 100 cases of empyema examined, it is quite remarkable to note that there were changes in the visual field in 70 with almost no change in central vision, or in the fundi. In only three cases was there optic neuritis. As showing wide variance from the experience of van de Hoeve and Klein, it is to be noted that of the 63 anterior sinus cases 48 had field defects and scotomas. Of the 9 posterior sinus cases 7 had field defects. Of the 70 empyema patients showing field defects 16 recovered after operation, 4 retained the former field defects, and the balance of 50 did not return for examination. There were 52 enlargements of the blind spot and 7 central scotomas, 28 of the 52 enlargements of the blind spot existed without other field changes, and 22 were combined with other field defects.

In bilateral empyemas there were 7 bilateral and 13 monolateral enlargements of the blind spot. In monolateral empyema there were 19 homolateral enlargements of the blind spot and 8 contralateral. The investigator examined 37 cases of non-purulent nasal disease, 11 of whom showed ocular changes. She found blind spot enlargement in hypertrophic rhinitis and atrophic rhinitis.

This question of central scotoma in its relation to the accessory sinuses is one of great interest. Leber many years ago (Graefe-Saemisch *Handb. d. Gsam. Augenh.*, Ed. 1, p. 814) called attention to retrobulbar neuritis occurring very suddenly with chlorosis and with slight fundus changes, suggesting that it might be due to a periostitis of the optic foramen. Of further interest in this matter is the splendid work of Onodi (*The Optic Nerve and the Accessory Sinuses of the Nose*) and the reader is referred to this volume if he wishes to be further impressed with the interesting connection between inflammation of the papillo-macular bundle and diseases of the sinus. For the present it is sufficient to say that Onodi states that dehiscence in a sinus wall may be the cause of optic nerve complications, as the mucous membrane under this dehiscence may come into direct contact with the orbital periosteum, and thus in direct contact with the dura and sheath of the optic nerve. Onodi deals at further length with this subject in an article entitled Dehiscence in the Walls of the Nasal Accessory Sinuses (*Arch. f. Laryn.*, Bd. XV).

Foster Kennedy (*Amer. Journal Med. Sci.*, Sept., 1911, p. 355) records six cases of tumor, or abscess, of the frontal lobe of the brain, producing central scotoma on the same side by direct pressure behind

its entrance into the optic foramen. Ward Holden (*Trans. Am. Med. Assoc.,* 1914) states he has also observed two cases of this kind.

Concerning post-operative visual disturbances and blindness of nasal origin, Onodi reviews the literature of this subject (*Zeitsch. f. Augenh.,* March, 1914), finding 13 cases up to that date. He reports the cases of traumatic indirect fracture of the optic canal as collected by Hoelder, who found fifty-three. Freudenthal published a case of blindness of the left eye after the Killian operation. Oppenheimer and May reported a similar case, and Quix a case of diminished vision and narrowed fields occurring on the same side after the operation. Senator had a case of blindness immediately following intracranial opening of the frontal sinus. Onodi explains these by supposing an indirect fracture of the optic canal during the operation. Onodi reports the case of Laas and Lewy in which following the removal of a septal spine situated posteriorly there ensued a large defect in the visual field with pallor of the papilla. Kuttner and Lehman observed left amaurosis and right temporal hemianopsia after removal of an exostosis of the septum with the electric saw, and Hintner reports the same condition after practically the same operation. Purtscher had complete bitemporal hemianopsia following polypi from the middle meatus. Marsh describes two cases of blindness after removal of the middle turbinal caused by indirect fracture of the optic canal from forcible turbinectomy.

Effect of traumatism upon the field of vision. Contusion of the eyeball and orbital margin may result in optic atrophy and changes in the fields. Evans (*British Med. Journal,* July, 1905) reports ipsolateral temporal hemianopsia from blows on the external angular processes, and says that blows upon the upper border of the orbital margin are often associated with loss of the central part of the field.

Lang, Lawson and Hepburn all report cases of field changes from injury to the eyeball. Laas (*Zeit. f. Augenh.,* Aug. 1907) observed loss of the upper half of one field after submucous resection of the septum. Posey (*Ophthal. Record,* May, 1911) reported a case of contracted color-field, but normal for white, after a blow causing fracture of the malar bone and orbital plate.

In the more serious injury of the cranium itself, as well as injury to the brain, we may have all degrees of changes in the fields from the slightest to complete amaurosis. The writer has had two interesting cases under his observation where a bullet in each instance passed from one temple to the other, transversing the *apex* of each orbit, with complete and sudden amaurcsis that was permanent. The ophthalmic signs were interesting, the retinæ being in all of these eyes spotted

throughout with hemorrhages of various sizes, which occurred in the superficial retinal layers. These did not extend into the vitreous.

T. Inouye (*The Visual Disturbances from Shot Wounds of the Cortical Visual Centers from Observations of the Wounded in the Last Japanese War*, Leipsig,-, 1909) reports 30 cases of gun-shot wounds of the cortical visual area, and found a great variety of field changes, as follows: Right and left hemianopsia; inferior and superior hemianopsia, scotoma and concentric contraction; and various other irregular field defects. Reports of hemianopsia from bullet wounds are not rare, and it is not necessary to report such in detail. It is, however, interesting to observe that in a number of such the limiting line of the hemianopsia passed exactly through the macula, and James (*Ophthal. Rev.*, Nov., 1910) has reported this occurrence after fracture of the base.

Fisher describes two cases of altitudinal hemianopsia from bullet wounds of the occipital region, in each of which the macula was spared and good central vision present.

As indicating the possibilities of improvement in the field after severe injuries to the eye, the writer has had several cases where injury of the eyeball by penetrating steel caused, for a time following the injury, scotomas of varying degree, which after some months have failed to show in the visual field. He may also add an interesting case reported by Lewis (*Annals Oph.*, Oct., 1912, p. 736) where after gun-shot wound of the eye the vision one month after was only 2/200. The wound had been a double perforation of the eyeball, and when six months later the eye was refracted vision was normal, and the visual field, with the exception of a small scotoma—evidently corresponding to the retinal injury—was also normal in its outer extents.

As showing the variability in duration of visual field changes after accident we may note cases such as reported by Newmark (*Journal of Ophthal. and Oto-Laryng.*, Vol. VIII,—5, 1914) in which after injury to the back of the head, with total amaurosis after a period of three hours, large white objects could be perceived. In four hours after fingers could be counted, but there was a right homonymous hemianopsia. The fields gradually extended until the second day when they were normal. The case probably suffered from commotio-cerebri. The second case, by the same writer, after a blow on the jaw was blind for three weeks. After three months the fields showed residual areas for white, which status remained permanently. Newmark thinks the visual field changes are due in some of these cases to traumatic affection of the occipital lobes.

Pregnancy, parturition and changes in the sexual organs. Parturi-

tion may be accompanied with great loss of blood and partial, or complete, loss of the fields, temporary or permanent. Nettleship reports four cases of retrobulbar neuritis. The case of Moore's following uterine hemorrhage has already been reported.

Night-blindness has also been recorded. In rare cases of this nature the true relationship of the symptom to its ascribed cause may possibly be a matter of uncertainty. Knies states that retinal hemorrhage and optic nerve atrophy, accompanied by changes in the fields, may be due to excessive sexual intercourse.

Dor (*Soc. Trans. d'. Ophtal.*, Jan., 1884) reports changes in the field in a girl of fourteen who had hemorrhage into the vitreous at her first menstrual period, which absorbed to again occur at each succeeding period until menstruation was fully established. Transient amblyopia and even hemianopia may occur during menstruation, but, of course, the hysteric field as a possible factor must always be kept in mind in these cases.

Leoz Ortin, Madrid (*Archives de Optalmologia.*, Sept., 1914, p. 465) reports total bilateral hysteric amaurosis of short duration in an unmarried woman associated with the menstrual period. Vision returned during the night and was apparently normal the next day. There was some inversion of the color fields.

Forti (*Archiv. di Ottalmolog.*, Vol. XVII, p. 8, 1910, and *Ophthalmic Review*, 1910) states that he investigated the conclusions of Bellinzoni and Fridondani regarding the changes in the visual field occurring in pregnancy, which were as follows:

1. That a bilateral limitation of the fields does occur in pregnancy.
2. That the left eye is generally more severely affected than the right.
3. That this restriction consists not in a uniform or concentric contraction, but in a bitemporal pseudo-hemianopsia, a limitation of the fields in the temporal areas.
4. That these alterations are more evident in primiparæ than in multiparæ, and that they progress as pregnancy proceeds.
5. That there is no tendency to dyschromatopsia or achromatopsia.
6. That the accuracy of vision is not in any way interfered with.

Hence Forti concludes:

1. That there is a very slight limitation of the nasal field and a decidedly more definite restriction of the temporal.
2. That the eyes are equally affected.
3. That the alteration is more marked in primiparæ, but is not adversely affected by the advance of pregnancy.

Forti found that the color-fields were constantly and irregularly

altered, and at times there was inversion of the fields. He agrees with the writers named that the changes are of a functional nature, and thinks that this is shown from the fact that the right eye was probably examined first, thus leaving the left eye in a state of fatigue at the commencement of its examination.

Evans (*Oph.*, Jan., 1912) remarks that the changes found, in being thus associated generally with an hysteric state, indicates that there may be some changes in the pituitary gland, as hypertrophy of the hypophysis is known to take place during pregnancy. The writer, from a number of fields taken during pregnancy, has not found such marked changes in the fields as described by Forti, Bellinzoni and Fridondani, and where limitation of the field occurred there was suspicion of hysterical causation. In pregnancy it is a well known fact that hemorrhage may occur in the retina without known cause, and that these areas may appear as relative or absolute scotomas that usually disappear without leaving a trace.

Holden (*Journal A. M. A.*, July, 1914) reports a case of absolute central scotoma in each eye in the seventh month of pregnancy where the symptoms showed renal changes. The scotomas rapidly disappeared after the induction of labor, although there was some slight pigmentation in the macular region and night-blindness. The characteristic lesion in eclampsia is a more or less edema of the intracranial tissues and from this diffuse pressure we may have complete transitory blindness, and in the presence of normal fundi. In these cases Holden believes that edema of the anterior lobes, or of the meninges, brought about pressure on each optic nerve near its origin.

A brief summary of occasional field changes in certain other systemic diseases. Here will be briefly considered those diseases in which, with our present knowledge, the field changes are either not characteristic, or are infrequent and non-important.

(a) *Friedreich's disease.* This disease, bearing some resemblance to locomotor ataxia in general symptomatology, in contrast to the latter has a remarkable absence of eye symptoms. However, a closely-related form of ataxia described by Pierre Marie and known as "Marie's ataxia" has been described, with loss of central acuity and changes in the form as well as in the color-fields, although these cases were not characteristic.

(b) *Meningitis.* With both pachymeningitis and leptomeningitis we may have pressure causing papillitis and changes in the fields.

(c) *Progressive myelitis.* This has, as a rare complication, central scotoma, contracted fields and unilateral color-blindness.

(d) *Paresis.* Dercum (Posey and Spiller, *Diseases of the Eye and*

Nervous System, p. 488) states that disturbances of the visual field may occur in paresis, but that these disturbances are uncommon. Restriction may be noted, however, as in a case reported by Deutsch. Dercum further speaks of a case in which after an epileptiform seizure a left hemianopsia was noted which persisted for years.

(e) *Syringomyelia.* Concentric contraction of the visual field especially for colors was noted in 38 of 130 cases collected by Schleisinger.

(f) *Coal miner's nystagmus.* Visual field changes have been found in coal miner's nystagmus. These consisted in concentric symmetrical form and color contraction, regular in type, but occasionally interlacing of the red and blue. Cridland (*Ophthalmoscope,* Dec. 1913) has examined about 60 such cases. In one case the contraction for white was temporal to the 20° circle, and elsewhere to the 10° circle. Red was only recognized at the fixation point. He found that the field improved as the disease improved. There was a similarity in these fields to cases of traumatic neurosis.

(g) *Tuberculous disease.* This disease has nothing distinctive in the visual changes resulting from it. In diffused tuberculosis of the choroid we may have absolute small scotoma, and in tuberculous disease of the base of the brain we may have tuberculous foci of disease that may affect the fields from pressure on the visual paths just as in any other intracranial disease. In this connection it is interesting to note that the hypophysis may show tuberculosis, as in a case reported by Verhoeff (*Journal A. M. A.,* July 4, 1914) in which the enlargement of the hypophysis was about ten times its normal size, and in which the vision was much reduced. There seems to have been been but two other such cases reported.

(h) *Oxycephalus* or tour-skull (Turmschadel) may cause changes in the visual field, many cases of disordered vision with related fundus changes having been reported. Since intracranial pressure is present in many of these cases, and since distension of the third ventricle is found, it is very probable that grave visual field defects of various characters would be found in these causes. Gordon (*N. Y. Med. Journal,* Jan. 7, 1911) reports a case of oxycephalus with contraction of the fields of vision. Patton (*Annals of Ophthalmology,* April, 1914) writes upon the ocular disturbances associated with this condition. Mackenzie recognized as long as fifty years ago a definite relation between what he at that time called chronic hydrocephalus and disturbances in vision.

Various theories have been advanced for the relationship between the cranial deformity and the ocular symptoms which so frequently accompany it. Virchow believed that the deformity was due to prenatal closing of the fontanelles. Dorfmann, from a study of three cases,

and the reports of others, believes that this early closing of the sutures results in an intracranial pressure which causes optic neuritis with secondary atrophy. This is the opinion of many other writers on this subject. The vision and the visual field in these cases is often difficult to obtain owing to the low mentality of many of the cases.

In Patton's cases the form- and color-fields were moderately reduced and the radiograph showed the posterior halves of the wings of the sphenoid were depressed to a level of the floor of the sphenoid. Patton, in his article, concludes:

1st.—That while the condition has been recognized since the days of Mackenzie, its etiology is not clearly established.

2nd.—The gravity of the condition in its relation to the eye should be recognized early.

3rd.—Radiographic studies are useful in showing the degree of deformity in the region of the chiasm and orbital roofs.

4th.—Although operative measures have been disappointing, decompression offers some hope of relief.—(H. McI. M.)

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[H. McI. M.]

Perineural space. The space around the optic nerve in the orbit.

Perineuritis. Inflammation of the optic nerve-sheath of one or both eyes. It is almost invariably due to some general cause—often syphilis or tuberculosis—but may result from infections or traumatic processes in the orbit. As a result of any of these factors there is a small-cell infiltration into the subvaginal space. Signs of papillitis are noted with the ophthalmoscope, vision being impaired according to the severity of the process. Pain, referable to the orbit, is generally present. Eventually the inflammation extends to the nerve proper. An exact diagnosis is difficult, and the prognosis depends upon the amount of damage done to the nerve. Optic atrophy may ensue. The treatment must be directed to the cause of the lesion; if pus or much infiltration be present surgical intervention may be needed.

Perinuclear cataract. See **Zonular cataract.**

Periocular. Circumocular. Surrounding the eyeball.

Periocular space. The space within the orbit not occupied by the eyeball.

Periodic ophthalmic literature. See **Ophthalmology, Literature of.**

Periophthalmia. Periophthalmitis. Inflammation of the tissues about the eye.

Periophthalmic. Perioptic. Periocular. Circumocular; orbital with reference to the eye; around the eyeball.

Periophthalmitis. Inflammation of the tissues around the eye.

Periophthalmus. A remarkable genus of acanthopterous fishes, allied to the gobies. Their eyes protrude and are very mobile; their pectoral fins can be used as legs. Several species occur on the coasts of the Indian Ocean. Of these the best known is *Periophthalmus kelreuteri.* This fish lives about low-tide mark on the muddy flats or among rocks, and by means of its pectoral fins and tail hops along in search of crustaceans, insects, and gastropods. Respiration seems to be effected through the skin of the tail even more than by the gills. See **Comparative ophthalmology.**

Perioptometry. A term applied by Gillet de Grandmont to measurements of the peripheral acuity of vision, or of the limits of the visual field.

Periorbita. Periorbit. The periosteum of the orbit.

Periorbital. Of, within or about, the orbit.

Periorbititis. Periorbitis. Inflammation of the orbital periosteum.

Periorbitis. Inflammation of the periorbita.

Periostitis of the orbit. See **Orbit, Abscess of the.**

Periotomy. Removal of a band of conjunctival and subconjunctival tissue from round the cornea, for the relief of pannus. See **Peritomy.**

Peripapillary. Surrounding or about the optic papilla.

Peripapillitis. A (supposed) inflammation at the periphery of the optic disc.

Periphakitis. (Obs.) Inflammation of the capsule of the crystalline lens.

Peripheral. Peripheric. Of or situated at the periphery or boundary line.

Peripheral vision. That outside the macular region.

Peripheral paralysis of ocular muscles. That resulting from lesions of the peripheral neurons; they may be either orbital or basal.

Peripheraphose. Any phose or phosphene originating in the eye or optic nerve.

Periphery. (a) The circumference of a circle or the boundary line of any closed figure. (b) The surface of a body.

Periphlebitis retinalis. Inflammation of the external walls and surrounding tissues of the retinal vessels.

J. Igersheimer (*Graefe's Archiv f. Ophthal.* Vol. 82, p. 214, 1912) describes three cases of tubercular origin in adolescents. In a patient of nineteen years, the right eye showed an extensive disturbance of the retinal veins, mainly peripheral, and consisting of numerous fine, and some larger, hemorrhages in the retinal tissue. The other eye showed retinitis proliferans.

Tuberculous etiology was favored by the presence of tuberculosis in the patient's mother, a positive finding in the lungs of the patient, and pronounced tuberculin reactions. The second case was a typical one of recurrent juvenile vitreous hemorrhage, with changes in the retinal veins of the other eye. In the latter eye the old chorioretinitic foci were almost all situated along the vessels, and especially at their bifurcations. The lesions were almost entirely peripheral. The lungs were tuberculous and there was a marked reaction to tuberculin. In a case of greyish opacities over the retinal veins, a tuberculous etiology was doubtful.

Rose Steffan (*Archiv f. Augenheilk.*, p. 299, Nov. 1913) claims that it was Gilbert who first drew attention to the fact that in the tubercular variety the optic nerve may also become involved. Gilbert reported the atrophy of the optic nerve in a male of twenty years, where there was only one retinal hemorrhage, and no visible vessel-wall disease of the retina. Siegrist then compared two types of this disease. In the one form the optic nerve and the principal branches of the central vein are entirely normal and the inflammatory periphlebitic changes are found in the smallest branches of the retinal veins in the periphery. In the other form the periphlebitic changes occur in the principal branches of the central vein, with an optic neuritis. Steffan gives the details of a case of the latter type, with participation of the optic nerve, and thickening of the end branches of the veins. The course was interesting, in that during several months' observation, there appeared many vitreous and retinal hemorrhages. The case forms evidence, therefore, for the supposition of Gilbert, that circulatory derangement occurs on the stem of the central vein with involvement of the optic nerve. The second case reported is of interest, because of the etiology: The twenty-three year old patient acquired lues a year before. Two months previous to the examination, there occurred sudden disease of the left eye, when retinal hemorrhages were found. The patient was put upon antisyphilitic treatment. When the patient was seen by Steffan, a diagnosis was made of right, hemorrhagica retinalis, periphlebitis retinalis; left, retinitis proliferans. This was the first typical

case since Axenfeld and Stock's report on the tuberculous nature of this disease, which has been shown to be due to acquired lues in the secondary stage. As, in the older literature, there has been occasionally reported the appearance of retinitis proliferans after retinal bleeding in young syphilitics, so syphilis must be considered as an etiological factor in rare cases.

Finally, Fleischer (*Klin. Monatsbl. f. Augenheilk.*, June, 1914) observed in a man of thirty-six years, suffering with pulmonary phthisis, a periphlebitis of the retina with accompanying hemorrhages. They healed gradually. A year later a retinal inflammation of hemorrhagic nature appeared in the other eye. This was associated with a fresh nodular iritis. A half year earlier a papillitis had been observed in this eye. Glaucoma came on in the course of the acute iritis, and an enucleation had to be done a year and a quarter after the initial examination. There was no questioning the assumption that the double-sided periphlebitis retinæ with the sequelæ rested on a tuberculous basis. Histologic examination showed widespread tuberculous changes in the anterior portion of the bulbus, as well as similar phenomena throughout the veins of the retina. Fleischer believes that his findings prove that the retina is less rarely involved in the tuberculous process than was at first supposed. The involvement appears in a form which produces a clinical picture, because of the vascular relationship, which leaves no doubt as to the tubercular nature of the disease. This was first stated positively by Axenfeld and Stock.

Peripupillometer. An instrument for measuring the extent of the pupillomotor area of the retina and the value of the pupillary reaction. Schlesinger (*Deutsch. med. Wochenschr.* Jan. 23, 1913) has approached these problems in a new way. In the first place an absolutely constant source of light is required for a measuring apparatus, which works with variations of minute intensities of light. The author found this fact in the acetylene light, because electric illumination can not be used. The second problem is that of the diffuse light of dispersion. The diascleral light not only prevents exact measurements, but, as C. Hess showed, on striking the blind spot, elicits a pupillary reaction by dispersion. Then, the size of the image of a luminous object on the retina varies with anomalies of refraction. As it is very probable that, at the same intensity, luminous surfaces of different sizes have different pupillomotor values, an arrangement is necessary which allows one to focus exactly on the retina the image of a luminous object of equal intensity and size in all states of refraction. Finally every accommodative movement must be excluded.

Schlesinger's peripupillometer was constructed by Carl Zeiss, of Jena, for the solution of these problems. His results were: 1. In normal persons of the same age the value of the test is almost constant. 2. The pupillary reflex after repeated exposures to the exciting light at short intervals shows symptoms of exhaustion. 3. The time of reflex, i. e., the time intervening from the moment of exposure to the light to the visibility of the contraction, decreases after repeated radiations.

It is a fundamental condition, that any examination of the reflex area of the fundus must start with the determination of the value of the pupillary reaction. This conclusion follows from the observation that a weak light of the size of 1/50 of the optic disc directed upon the blind spot produces a pupillary reaction and the perception of a halo, but not if the intensity falls below from 0.3 to 0.4 candle power. Therefore, only intensities of light can be used which emit light of dispersion below a certain value. The radius of the reflex area of the retina equals the tangent of the angle of incidence multiplied by the posterior focal distance, and is at least 5 mm. in healthy persons of middle age. Hess found 3 mm. Schlesinger succeeded with his apparatus in ascertaining the hemiopic pupillary reaction in two cases.

Periscope. An optical instrument by means of which objects can be seen through a vertical tube. See **Hyposcope,** p. 6121, Vol. VIII of this *Encyclopedia*.

Periscopic. Giving distinct vision obliquely as well as axially.

Periscopic lens. A concavo-convex lens, either of meniscus or contra-meniscus (q. v.) form. The name is specially applied to spectacle-lenses, the concave surface being worn next the eye, that produces a wider field of view. See, also, **Lenses and Prisms**; also p. 7414, Vol. X of this *Encyclopedia*.

Periscopism. The faculty of periscopic vision.

Periscyphisis. Periscyphismus. Periscythisis. Periscythismus. Periscytisis. Periscytismus. Scalping; an old operation which consisted in making an incision entirely around the cranium as a remedy for headache, eye trouble, etc.

Perithelioma. A neoplasm springing apparently from the adventitia of the blood vessels.

An example of this rare new growth, arising from the *central retinal vessels*, is reported by Schieck (*Archiv f. Ophthalm.*, Vol. 81, p. 199, 1912) who finds its only recorded parallel in a case studied by Salzer some twenty years before. The latter, however, was a perithelioma arising from the central retinal artery in the orbit and the invasion of the eye was only secondary. But in Schieck's case the growth arose

directly from the central artery after its passage through the lamina cribrosa. The patient was a man of 26 years. From March, 1911, there was progressive loss of vision. Examination of the fundus showed a round, reddish swelling in front of the disc, and prominent 4 D. The surrounding retina was swollen and hazy, and the retinal vessels disappeared at the border of the growth. A tentative diagnosis of tubercle led to treatment with tuberculin; but the tumor became steadily larger, vision was reduced to fingers at 4 m., and separation of the lower half of the retina occurred. The eye was therefore enucleated in October, 1911. There was no invasion of the optic nerve or of the coats of the eye. The tumor measured 2.2 by 3.3 mm., and was sharply delimited from all adjacent tissues except the blood vessels. It consisted principally of large polygonal cells having a decided resemblance to epithelial cells. There were very numerous blood spaces, lined merely with a delicate endothelial membrane. The growth was intimately related to the central vessels. The endothelium of the vascular intima was normal, but the cells of the adventitia showed marked proliferation, being surrounded by layers of spindle-cells. The tumor is therefore to be regarded as a perithelioma of the central retinal vessels.

J. Eicke (*Klin. Mon. f. Aug.*, 51, I, p. 588, May, 1913) removed from the skin of the right upper lid of a healthy woman, aged 35, a cone-shaped, soft, elastic, movable tumor of the size of a pea. The microscopic examination of the tumor revealed large polymorphous cells, grouped around small vessels and in independent heaps. Mostly the cells lay very close, at other places they were separated by fibrous tissue. The central parts were in mucous transformation and contained only immediately around the vessels characteristic accumulations of cells. The whole tissue was surrounded by a capsule. From this arrangement of the cells around the vessels and their large and peculiar form, the author diagnosed the tumor as perithelioma.

R. S. Lamb (*Trans. Am. Acad. Opht. and Otolaryng.*, p. 111, 1912) has also described a perithelioma of the eyelid, while the same tumor has (but rarely) been found in the cornea, ciliary body, retina and other ocular tissues.

Peritomy. This operation, which consists in simply detaching the conjunctiva at the corneo-scleral junction without excision, is also known as *circumcisio conjunctivæ;* both terms, the latter a coinage of Critchett, being inadequate and inexpressive of the position of the operation.

It is useful for the lessening of the vascular condition of the epithelial covering of the cornea in so-called trachomatous pannus and some

cases of extensive superficial corneal ulceration. It has been employed for the removal of increased superficial corneal vascularization, chronic conjunctivitis, episcleritis, glaucoma, herpes, and keratoiritis, by temporarily (or even, permanently), removing the superficial vascularization of the parts which are both directly and indirectly supplied by the vessels of the conjunctiva. Agnew has used it to advantage in persistent pannus. Vacher has made excellent use of what he terms igneous peritomy, which consists in a circumcorneal cauterization, in the treatment of corneal sclerosis and episcleritis. Cullere (*Thése de Paris,* 1886-1887, Num. 195) describes a similar proceeding. In the so-called crassus and sarcomatoid varieties of pannus, Panas (*Traité des Maladies des Yeux,* 1894, I., p. 230) has recourse to the same form of medical treatment. Van Lint (*Ophthalmology,* April, 1905) makes successful use of what he terms electrolytic peritomy. By its employment, the smallest vessels disappear and the cornea regains its transparency. The electrode consists of a platinum sphere of two millimeters' diameter situated upon the end of a curved tip which is connected with a de Wecker instrument. The positive pole is placed on the side of the eye which is to be operated upon. A current of two milliamperes is used. The current is allowed to flow for about ten to fifteen minutes' time.

Snell strongly recommends the method in diffuse keratitis, especially in those cases which evidence salmon-colored patches at the corneal periphery. He also employs it in recurrent ulcers, particularly in the old and the middle aged. In his hands (in more than two hundred cases), the healing was more rapid, and the corneæ cleared sooner and better than with any other form of treatment. Beard (*Ophthalmic Surgery,* 1910, p. 355.) employed a modification of the plan, by which he destroyed the trunk of a few large scattering vessels at the limbus corneæ by means of the galvano-cautery.

Prouff (*Bulletins et mémoires de lat Société francaise d'Ophtalmologie,* 1886, p. 112) has observed the curative powers of partial peritomy made upon grave ulcers and abscesses situated more or less in the corneal periphery.

For the performance of peritomy, the eyeball and its adnexa are thoroughly cleansed, and their exposed surfaces are analgized by the employment of cocaine. A fold of conjunctiva just beyond the corneoscleral junction is lifted by a pair of fixation forceps, and a small incision is made into it by a pair of sharp, curved scissors. The bulbar or peripheral edge of the incision is then dissected back until a band of conjunctiva of about two or three millimeters' width is made around the circumference of the cornea, just as far as may be necessary to

include the over-vascularized area. Any undisturbed vessels remaining in the exposed area are either divided or obliterated by the actual cautery, or better, by the galvano-cautery. After the procedure, the conjunctival sac must be thoroughly cleansed with a hot solution of boric acid or chloride of sodium. A drop or two of a weak solution of neutral sulphate of atropine is to be instilled, and a monocular fixation bandage is applied.

Reaction, as a rule, is very slight. The case is to be dressed daily. If the conjunctiva at any of the first dressings, shows a tendency to draw itself into its primary position, it is to be loosened and freed by the aid of a flat spatula.

In Agnew's procedure, the severed portions of the conjunctiva are pushed backward "to a distance of five millimeters by means of a convex-edged scalpel. With the same instrument, the episcleral tissue is also scraped away till the sclera is quite bare, and, where practical, the scrapings are excised. The larger trunks of the corneal vessels are gently scratched longitudinally with the point of the knife, or, what is perhaps better, each of them is touched where it crosses the limbus with a small, red hot, bulbous electrode. No clots of blood nor shreds of fibrin should be left about the field of operation."—(P. A. C.)

Peritomy, Furnari's. Removal of a broad strip of ocular conjunctiva around the entire circumference of the cornea, together with as much of the thickened corneal tissue at the limbus as possible; done in cases of obstinate pannus in order to reduce the blood supply to the inflamed cornea. See **Peridectomy.**

Peritor. A trade name for a grinding compound especially adapted for the roughing or first grinding of lenses.

Peritoric. A trade name for a certain kind of toric lenses.

Perivasculitis retinæ. A term applied to any condition exhibiting white borders to retinal vessels but, as Weeks (*Text-Book*, p. 439) points out, should be confined to those cases in which the lymph spaces are distended and occupied either by exudates or small cells or both, the lumen of the vessel being little or not at all altered.

In edema of the retina white bordered arteries (and occasionally veins) may be seen near the papilla, with distension of the perivascular spaces.

This condition may be independent of their diseases but it generally accompanies some inflammatory state of the optic nerve or retina, and is to be treated accordingly.

Perkinism. An obsolete form of suggestive therapeutics in which the treatment consisted in rubbing on the skin two "tractors," or pointed rods made of different metals.

Perkins institute. See **Institutions for the blind.**

Perléche, Ocular relations of. This is a contagious, eczematous, microbic disease which attacks the angles of the mouth in children, in which tissues are sometimes formed.

Ishihara (*Klin. Monatsbl. f. Augenheilk.,* Oct., 1912) finds it to be very common in Japan and to be due to the diplobacillus of Morax-Axenfeld. Eyes inoculated from such lesions develop a typical blepharo-conjunctivitis. The treatment of such mouth lesions is a measure of prophylaxis against possible eye disease. Ishihara some time ago pointed out that blepharo-conjunctivitis probably follows the skin disease and considers it proved by finding the diplobacillus in the mouth lesion.

Perl's test. This is a reaction for testing the presence of iron in the eye. See Ball's *Modern Ophthalmology,* p. 837.

Pernicious anemia. For the eye signs, see p. 420, Vol. I, as well as under **Neurology of the eye,** p. 8355, Vol. XI of this *Encyclopedia.*

Peronin. Dionin. The use of *dionin* in the early stage of senile cataract of the ordinary type dates from its first introduction by Wolfberg (under the name peronin) which he described in the third volume (1899) of the *Wochenschrift f. Therapie des Auges.* Later, Merck introduced ethyl-morphine hydrochloride under the trade name of dionin, displacing the benzyl-morphine hydrochloride or peronin.

Peroxidase. Any ferment that produces oxidation and reduces hydrogen peroxide to water by liberating oxygen. It is recommended by some as an application in various forms of conjunctivities. See *Annals of Ophthalmology,* p. 725, 1913.

Persistence of vision. The phenomena of subpermanent positive or negative after-images in the eye.

Persistent hyaloid artery. See p. 6072, Vol. VIII of this *Encyclopedia.*

Persistent pupillary membrane. See p. 2839, Vol. IV of this *Encyclopedia.*

Personal injuries in ophthalmic surgery. See **Visual economics**; as well as **Insurance in ophthalmic cases**; also **Injuries of the eye**; and **Legal relations of ophthalmology.**

Perspective. This is the art of representing natural objects upon a plane surface in such a manner that the representation shall affect the eye in the same way as the objects themselves. The distance and position of objects affect both their distinctness and apparent form, giving rise to a subdivision of perspective into *linear perspective,* which, as its name denotes, considers exclusively the effect produced by the position and distance of the observer upon the apparent *form* and *grouping* of objects; while *aërial perspective* confines itself to

their *distinctness,* as modified by distance and light. After the ''scope'' (i. e., the number of objects to be introduced, and the distance at which they are to be viewed) of the picture has been determined, and before the design is commenced, it is necessary to draw upon the perspective plan three lines: (1) The *base line,* or *ground line,* limits the sketch towards the operator, and is the base line of the picture. (2) The *horizontal line* represents the ordinary position of the sensible horizon. (3) The *vertical line* is drawn from the supposed position of the sketcher, perpendicular to the *ground* and *horizontal* lines, meeting the latter in a point which is called the *point of sight,* or center of the picture.

All lines which in nature are perpendicular to the ground line, or to a vertical plane which is raised upon it as a base, meet in the point of sight, which thus becomes their *vanishing point.* All parallel straight lines in nature are no longer parallel when projected on the perspective plane, but meet in a vanishing point; and, since the bodies drawn below the horizontal line are seen as if from above, those above if from below, and those to the right and left of the point of sight as if observed from the left and right, it follows that straight lines which in the picture are above the horizontal line lower themselves, those below raise themselves to it, whilst those to the left, following the same law, direct themselves to the right, and vice versa.

Aërial perspective consists in a modulation of the brightness and colors of objects in accordance with the state of the atmosphere, the depth of the body in the perspective plane (i. e., distance in nature from the ground line), and other accidents of place and time. As the distance of objects increases, their illuminated parts are made less brilliant and their shaded parts more feeble.

A thorough knowledge of perspective is a *sine qua non* to the painter or designer. Perspective was known to the ancients, but seems to have become extinct during the disturbances that convulsed Italy, and was revived by Albert Dürer and Bramantino of Milan (c. 1470-1535), whose body of rules was extended and completed by Peruzzi and Ubaldi about 1600. Dr. Brook Taylor in 1715 and 1719 was the first Englishman who discussed the subject scientifically. (*Standard Encyclopedia*). See, also p. 108, Vol. I of this *Encyclopedia.*

Perspective-glass. A terrestrial telescope or spy-glass.

Pertosse. (It.) Whooping cough.

Pertussis. See **Whooping-cough.**

Pes corvinus. Crow's foot; a set of wrinkles at the outer canthus of the eye.

Pest. Same as plague.

Pest bacillus. The specific organism of bubonic plague. See p. 741, Vol. II of this *Encyclopedia.*

Peter the Spaniard. A distinguished physician (afterwards Pope John XXI) who was born at Lisbon near the beginning of the 13th century, and who died May 16, 1277, in his palace at Viterbo, Italy, as the result of injuries inflicted by a caving wall. He was a prolific writer, partly scientific and partly superstitious. Thus, he recommends for epilepsy the continuous suspension from the neck of a bit of paper on which are written the names of Saints Caspar, Melchior, and Balthasar (the three wise men from the East). He was also convinced that diarrhea could be occasioned in any one by packing that person's feces in hollow bones and then laying these in a river. The flow from the bowels would continue, he thought, as long as the bones lay in the stream.

Peter's best known work is entitled *Summulæ Logicales.* His medical works are: *Thesaurus Pauperum,* and *Liber de Oculis.* No less a person than Michael Angelo Buonarotti is said to have copied the last-named book, three centuries later, for his own personal use (Hirschberg).

The so-called *Liber de Oculis* would seem to be properly designated Breviarium Magistri Petri Hyspani de Egritudinibus Oculorum et Curtis. In addition to a brief introduction, the work consists of four parts. Of these, the first is a mere condensation from Constantinus Africanus; the second, a Tractatus Mirabilis Aquarum Quem Composuit Petrus Hyspanus; the third, a literal copy of the first "Book" of the *Liber Oculorum* of Master Zacharias; while the fourth is merely a collection of prescriptions, for the most part worthless.—(T. H. S.)

Peters, John Charles. A well known New York physician, who paid considerable attention to diseases of the eye. Born at 326 Broadway, New York City, July 6, 1819, he was educated at Nazareth Hall and at the College of Physicians and Surgeons of the City of New York. He afterwards studied at Berlin and Vienna, at the latter point receiving his medical degree in 1844. Settling in New York City, he soon had an excellent practice, first as a homeopath and later as a regular. He it was who introduced corrosive sublimate as a remedy for Bright's disease—a treatment which had a great vogue for many years. He edited, with Dr. Ely McClellan, *The U. S. Cholera Report for* 1873, and wrote a number of journal articles, a few of which relate to ophthalmology. He was president of the Medical Society for the county of New York for some years, and was one of the founders of the New York Pathological Society. He was an authority on cholera and yellow fever, and specialized in diseases of the brain, and diseases of

women. The *North American Journal of Homeopathy* was edited by him for a number of years, and among his publications were *Diseases of the Eye* (1854), and *Notes on Asiatic Cholera* (1866). He married May 16, 1849, Georgina, daughter of Andrew Snelling, Esq. He died in 1893.—(T. H. S.)

Petit, Canal of. See p. 1378, Vol. II of this *Encyclopedia*.

Petit canthus. (F.) Outer canthus.

Petit cercle de l'iris. Annulus iridis pupillaris.

Petit, Etienne-Pourfour du. Son of the great François-Pourfour du Petit, and himself a physician of some note. He was born at Paris, and there received his professional degree in 1746. The place and date of his death are unknown. He wrote *Remarques Addressées a l'auteur du Mercure de France sur l'extrait du Mém. de Daviel*, etc. In this remarkable composition he attempted, but without success, to show that cataract extraction was not original with Daviel, but had been already described by the mediæval Arabians, Avicenna and Rhades.—(T. H. S.)

Petit, François-Pourfour du. Father of Etienne-Pourfour du P. One of the most important ophthalmologists of all time. Born at Paris, June 24, 1664, he travelled extensively in the various countries of Europe before he began to study medicine. He received his professional degree at Montpellier in 1690, then made a specialty of surgery in the Hôtel Dieu, at Paris. In 1693 he accompanied the French army to Flanders, after which he served as physician in various military hospitals. In 1722 he became a Fellow of the Academy of Sciences. He died June 18, 1741.

Petit's chief services to ophthalmology were five in number, as follows:

1. He greatly improved the "couching" operation for cataract. His method was first to make an opening in the lower half of the posterior capsule of the lens, and then, slightly withdrawing the needle, to press gently forward upon the lens a very little higher than its center. The lens slid out of its capsule, and took a more forward position on the bottom of the eye than after the older method of operation. Thus, less reaction followed, and more eyes were saved.

2. Petit was one of the great supporters of "the new doctrine about cataract." Throughout antiquity, the middle ages, and even the earliest centuries of the modern period, a cataract was supposed to be a thickened and corrupted "humor" which had flowed down into a (wholly imaginary) space between the pupil and the lens. The operation performed for cataract throughout antiquity and until the time of Ammnar (an Arabian of the middle ages), was "depression," or

"couching." Ammnar introduced the procedure known as "suction." Still, however, a cataract was supposed to be an exudate between the pupil and the lens. Fabricius ab Acquapendente was the first to show that the lens lies virtually in contact with the pupillary border of the iris. Then Quarré, in the 17th century, taught, but did not actually demonstrate, that a cataract is really a hardening and opacification of the crystalline lens. Next, the German, Rolfinck in (1656) showed the truth of Quarré's teaching by actual anatomical demonstration. The new theory of cataract, however, spite of its great importance and its absolute truth, was permitted to be almost forgotten for exactly 50 years. Then Brisseau and Maitre-Jan revived the new-old doctrine, and fought for it vigorously, and, in spite of bitter opposition (led by Thomas Woolhouse) finally secured its unconditional acceptance for all time.

In this bitter and long-continued controversy, one of the ablest supporters of Brisseau and Maitre-Jan was the subject of this sketch —Francoiz-Pourfour du Petit.

3. For soft cataracts that could not properly be couched, Petit re-invented the operation of discission—a procedure still extensively employed.

4. He made a large number of accurate measurements of the ocular tissues and fluids—the first extensive as well as accurate measurements of these parts in all ophthalmologic history.

5. He discovered a number of important anatomical features of the human (as well as the animal) eye, the most important, probably, being the tiny canal which goes by his name today. This discovery he announced in these words: "I have discovered a small canal, running round the margin of the lens, which I call the plaited circular (canal circulaire godronné)." Petit's name was given to the structure by Zinn, the man for whom was named the ligament of Zinn.— (T. H. S.)

Petit, Jean Louis. A surgeon of great celebrity, and perhaps the finest operator of his time in France. Born at Paris Mar. 13, 1674, he was taught anatomy by the great Littré while still a mere boy in his father's house. In 1692, he became military surgeon, and, in 1697, assistant major-surgeon in the Hospital at Tournay. In 1700 he returned to Paris, and, after a brief course of study, received the degree of Master of Surgery. He wrote a number of works, the most important of which are: *The Art of Curing Diseases of Bone*, etc. (Paris, 1705); *Treatise on the Diseases of Bone*, (2 vols., 1723) and *Treatise on Surgical Diseases and the Operations which are Proper for Them* (3 vols., Paris, 1774). The last-named work, his most important writing, appeared posthumously.

In 1708 he extracted from the anterior chamber of the eye a dislocated cataract *via* an incision in the cornea. This operation, however, he was not the first, but the second, to perform. St. Yves had carried out a precisely similar procedure in 1707.

Petit died April 20, 1760.—(T. H. S.)

Petit's bacillus. This is a Gram-negative bacillus, which generally occurs in pairs, described first by Petit, as a cause of superficial ulceration of the cornea. In morphology and staining reactions it is identical with the bacillus of Morax and Axenfeld but is easily differentiated by its cultivation on agar-agar. See **Bacteriology of the eye.**—(S. H. M.)

Petit's eye salve. A popular ointment of variable constitution.

Pétrequin, Joseph Pierre Eléonor. One of the greatest of Lyonese surgeons and ophthalmologists. Born June 25, 1809, at Villeurbanne, near Lyons, he graduated at Paris in 1835. Two years later he travelled for a time in Italy; in 1839 in Swabia and northwestern France. In 1838 he became assistant major-surgeon at the Hôtel Dieu of Lyons, in 1844 surgeon-major, and in 1855 titular professor of surgery at the Hospital of the Preparatory School of Medicine and Pharmacy. He died June 3, 1876.

Pétrequin was a man of the greatest uprightness, and, though a trifle cold in manner to strangers, yet toward those he knew, both gentle and kind. His kindness toward the younger members of his profession was extreme.

Among his more important works of a general character should be mentioned:

1. *Traité Medico-Chirurgicale et Topographique.* (Paris, 1843. Many editions and translations. 45 pp. are devoted to diseases of the eye.)

2. *De l'Étude des Médecins de l'Antiquité.* (Paris, 1858.)

3. *Études Méd., Historiques et Critiques sur les Médecins de l'Antiquité et en Particuliers sur Hippocrate, Galien, Paul d'Égine,* etc. (Paris, 1859.)

4. *Mélanges d'Histoire de Littérature et de Critique Médicales sur les Principaux Points de la Science et de l'Art.* (Paris, 1864.)

5. *Chirurgie d'Hippocrate.* (2 vols., Paris, 1877, '78. One of the most important of all medico-historical compositions.)

His ophthalmic writings appear entirely as articles in the *Annales d'Oculistique*, from the first to the thirty-eighth volumes inclusive, and concern almost every important topic in our special field.—(T. H. S.)

Petrogen. This is a proprietary vehicle for iodine, phenol, camphor,

iodoform and other active remedies used in ophthalmology and general surgery. It resembles vasogen and in both liquid and semi-solid form is employed for the same purpose as that menstruum. It is marketed alone and in combination with the remedies just mentioned in various proportions from 5 to 50 per cent. In the liquid condition it readily dissolves iodine, mercury compounds, carbolic acid, ichthyol, etc.

Petrol. Motor spirit. Pétrole is the name given in France to our naphtha or gasoline, and like it is composed of the (heavier) hydrocarbons from crude petroleum that boil below 50° C. (122° F.). It is on occasions used as a solvent for remedies employed in ocular therapeutics.

Ferentinos asserts that biniodide of mercury dissolved in petrol reaches the tissues more readily than an aqueous solution, and that the vehicle itself is aseptic. He has used it in many external diseases of the eye, and regards it as a valuable aid to other remedies.

His formula is: Hydrarg. biniodidi, 1.00; petrol, 1000.00. One part to be mixed with three of liquid vaseline.

Petrolatum. Petrolatum U. S. Petrolatum spissum. This hydrocarbon differs very little from soft paraffin (q. v.) and closely resembles in all its characters common vaseline (q. v.). It is an unctuous mass of yellowish color; odorless and tasteless. It gives off, when heated, a faint petroleum smell. It melts at 48° C. (118° F.) It is insoluble in water and alcohol but is readily dissolved by ether and the fixed oils.

A white variety—petrolatum album—is official in the U. S. P., corresponding to the commercial article cosmoline.

White vaseline is ordinary vaseline filtered through animal charcoal, and in various countries where it is similarly treated, is known as soft paraffin, adepsine, chrisma, saxoline, geoline, and salvo petrolia.

Its common use is as an excipient for ointments. It should be prescribed instead of vaseline.

Petrolatum album. See **Petrolatum.**

Petrolatum molle, U. S. See **Cosmoline,** p. 3543, Vol. V of this *Encyclopedia.*

Petrolatum spissum. See **Petrolatum.**

Petroleum. Coal oil. A thick natural "mineral" oil of complex composition, chiefly light and heavy hydrocarbons. Its fumes are irritating to the eyes and workers in it occasionally suffer from a form of conjunctivitis.

Petrus Hispanus. See **Peter the Spaniard.**

Pettinato (ligamento). (It.) Pectinate (ligament).

Pfaff, Christoph Heinrich. A celebrated German internist at Kiel, Ger-

many, of some importance ophthalmologically. Born at Stuttgart, Mar. 2, 1773, he studied at Stuttgart and at Göttingen, returning, however, to Stuttgart to receive his degree in 1795. His dissertation was entitled "De Electricitate sic Dicta Animal." In 1801 he was made full professor of medicine, physics and chemistry at Kiel. In 1795 he published at Leipsic, *Ueber thierische Electricität und Reizbarkeit*, in which he announced a number of discoveries in connection with the ophthalmic electrical responses. He also wrote a number of works of a general character. In 1841 he was operated on by Jaeger in Vienna for "glaucomatous cataract," but (as has so often happened after operations on the eyes of ophthalmologists) with disastrous results. Two years later, he celebrated the semi-centennial of his doctorate, dying at Kiel, Apr. 28, 1852.—(T. H. S.)

Pfalz's stereoscoptometer. This instrument has been employed to determine the monocular estimation of depth, especially at considerable intervals of time after loss of one eye. The investigations of Cords and Bardenhewer (*Ophthalmic Year-Book*, p. 266, 1913) were directed to ascertaining whether the claims made for the instrument in this respect were trustworthy. Tables are given comparing the results obtained in normal individuals, in whom one eye was covered while the tests were made, and in persons who had lost one eye. In each case the trial was ten times repeated. The average number of failures with the Pfalz apparatus in twenty-five one-eyed persons was 3.9, and in twenty-five two-eyed persons 2.8. In the one-eyed the average period since the second eye had been lost was almost ten years. As a matter of fact, therefore, monocular estimation of depth was better in normal individuals than in those who for years had had to depend entirely upon a single eye. Further study indicated that repeated tests of the same individual with the Pfalz apparatus resulted in adaptation to the test, so that the patient's observations became more accurate. Upon this fact may depend the dissimilarity of results arrived at by various authors.

Pfeffel, Privy Councillor to the Margrave of Baden. The subject of this sketch seems to have lost his sight as the result of ophthalmia neonatorum. He established at Colmar a military school, and was also an author, having written six volumes of verse. He died at Colmar in 1809.—(T. H. S.)

Pfeiffer's bacillus. See **Bacillus influenzæ**, p. 736, Vol. II of this *Encyclopedia*.

Pfitzner's safranin stain. See p. 6910, Vol. IX of this *Encyclopedia*.

Pflüger, Ernst. A Swiss ophthalmologist, celebrated for his work on color vision and for his advocacy of lens extraction in high myopia.

Born at Bären a. d. Aare, July 1, 1846, he studied at Bern, Utrecht and Vienna, receiving his medical degree in 1860. In 1876 he was made extraordinary professor of ophthalmology at Bern, and in 1879 professor ordinarius at the same institution. He died Oct. 3, 1903.—(T. H. S.)

Pfropf. (G.) Embolus; graft.

Phace. (L.) Phacea. The crystalline lens.

Phacentocele. Dislocation of the crystalline lens into the anterior chamber of the eye.

Phacia. (L.) Lentigo, or freckles.

Phacitis. Capsitis. An old term for inflammation of the crystalline lens or of its capsule, or both.

Phacocatapiesis. Phacocatathesis. (Obs.) Couching or depression of cataract.

Phacocele. The escape of the crystalline lens from its proper place; a displaced eye-lens.

Phacocyst. A little-used synonym for the capsule of the lens.

Phacocysta. (L.) The capsule of the crystalline lens.

Phacocystectomy. Rognetta's operation for cataract by first cutting out a part of the capsule.

Phacocystitis. Supposed inflammation of the capsule of the crystalline lens.

Phacoglaucoma. The structural changes in the lens produced by glaucoma.

Phacohydropsis. (L). Morgagnian cataract.

Phacohydropsia. Serous infiltration of the lens.

Phacoid. Lenticular.

Phacoidoscope. Synonym of phacoscope.

Phacolysis. Same as phakolysis.

Phacomalacia. Softening of the lens; a soft cataract.

Phacometachoresis. Phacometecesis. (Obs.) Dislocation of the crystalline lens.

Phacometecesis. (Obs.) Same as phacometachoresis.

Phacometer. An instrument for measuring the refractive power of lenses. One of the best known is that of Tscherning.

Lucien Howe (*Ophthalmology*, January, 1912), after describing and picturing the phacometer and giving an easy way of converting the ophthalmometer into a phacometer by the removal of the prisms, and reviewing the formulæ useful in calculating the position of the lens and the changes which it undergoes during accommodation, proceeds to give a few of the results of observations by this method of research. First, the axis of the lens usually points slightly downward and toward

the temple at its anterior end. Second, during accommodation the entire lens apparently moves slightly downward. Third, the posterior surface of the lens changes but little during accommodation, and the anterior surface changes to a decided degree, the central portion assuming a kind of conical projection or bulging forward. The posterior surface also changes irregularly as compared with other parts. Fourth, it is evident that these changes produce astigmatism of irregular form, though of low degree, and must cause varied and unequal demands upon different parts of the ciliary muscle.

Phacomalacia. Soft cataract.

Phaconin. The globulin of the crystalline lens.

Phacoplanesis. Wandering lens; preternatural mobility of the crystalline.

Phacopyosis. An old term for supposed suppuration of the crystalline lens.

Phacoscleroma. PHACOSCLEROSIS. Hard cataract.

Phacosclerosis. Hardening of the eye-lens; a hard cataract.

Phacoscope. An instrument for measuring the changes in shape undergone by the crystalline lens during accommodation. It consists of a series of prisms so arranged that the observer sees two reflections of each image formed in the lens. The different positions of the lens are thus rendered more evident.

Phacoscotasmus. (L.) Obscuration or clouding of the crystalline lens.

Phacoscotoma. Cataract.

Phacosis. A black spot on the eye.

Phacotherapy. Heliotherapy.

Phacus. Lentigo, or freckles.

Phacydrops. PHACYDROPSIA. Morgagnian cataract.

Phæochrous. Of a dark or dusky color.

Phagedenic ulceration of the eyelids. Soft chancre of the lid.

Phagocyte. A term originating with Metschnikoff, to designate any ameboid cell regarded as a structure capable of inclosing and digesting solid particles. In the body they act in absorbing healthy tissues, as in the metamorphosis of batrachia and the development of bone; in active degeneration of parts in disease; and as scavengers, removing bacteria and minute solid masses that have accidentally reached the tissues.

Phak-. See the same words beginning with **Phac-.**

Phakitis. PHACITIS. A (supposed) inflammation of the lens.

Phakohymenitis. Inflammation of the capsule of the crystalline lens.

Phakolysis. Discission of the crystalline lens, followed by extraction.

Phakomalacia. Soft cataract.

Phakometer. See **Phacometer.**

Phakosclerosis. (F.) Senile type of cataract.

Phakoscope. See **Phacoscope.**

Phantasm. A visual hallucination or illusion; an apparition.

Phantasmagoria. A name invented in 1802 for an exhibition of optical illusions produced by means of the "magic" or projecting lantern. The word has since been applied to any rapidly or strikingly changing scene, and especially to a disordered or fantastic picture of the imagination.

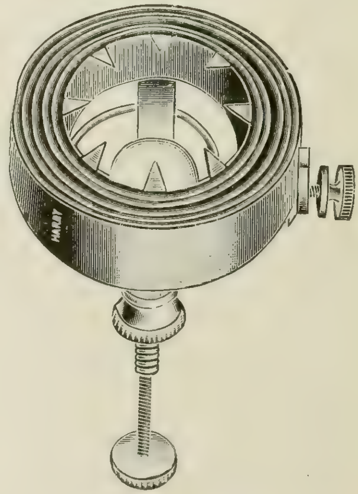
Phantasmograph. An apparatus for printing lantern slides.

Phantasmatography. A description of celestial appearances, as the rainbow, etc.

Phantasmascopia. PHANTASMATOSCOPIA. Synonyms of metamorphopsia.

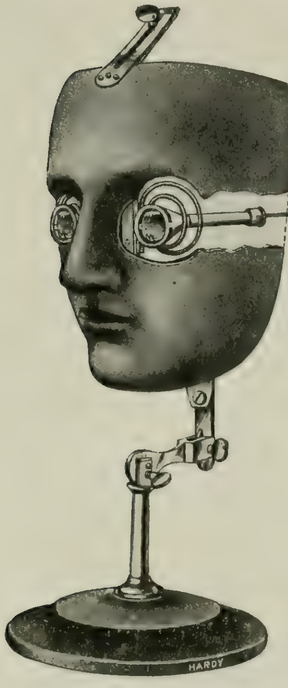
Phantom face. EYE PHANTOM. OPERATION MASK. A device for holding animal (pig, sheep, ox) eyes for the purpose of acquiring dexterity in

Vienna Mask.

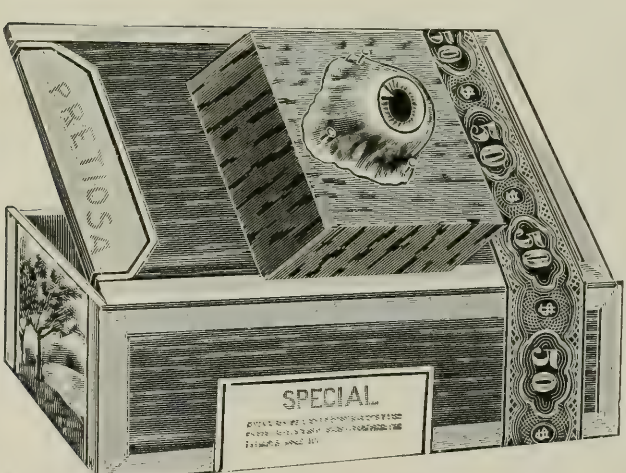


Eye Clamp for Vienna Mask.

operations requiring opening of the eye. Several ingenious means of holding pig's eyes for operations have been suggested but probably the best is the Vienna mask, which is a hard rubber mould of the



The Phantom Face.



Home Made Cigar Box Mask (Veasey).

human head, with openings for the eyes, into which is inserted by a spring and catch the serrated clamp firmly holding the pig's eye so that it gives much of the appearance and relationship to surroundings that would be present in the human eye. By an ingenious arrangement the eye can be fastened tightly or loosely, and the mask is usually arranged so that it can be placed in any position, imitating the position of the head of the human. Most of the other masks in the market, including the papier maché phantom faces (see the figure), are either good or poor imitations of the Vienna mask. For training the hand and following out the steps of various ophthalmic operations nothing excels operative work upon pigs' eyes in the Vienna mask.

For those who do not have access to a Vienna mask or do not care to purchase one, a cheap and very efficient mask may be prepared according to plans suggested by Veasey which consist in gluing a large, square piece of cork, about one-half or one inch thick, on the lid of a cigar box. The eye is fastened to the cork with tacks in the manner shown in the illustration, and the lid of the cigar box can be raised or lowered to secure any angle desired.—(A. E. B.) See, also, **Operative skill.**

Phantom intra-ocular tumor. Arnold Knapp (*Archives of Ophthalmology,* Nov., 1911) reports a case similar to those previously described by Haab and Pagenstecher. The patient, a woman, was 73 years of age. Symptoms had been present six months, and consisted of first redness and later protrusion. V. = 20/70. Disc normal. There was a shallow detachment below in the periphery of the fundus. On dilating the pupil a round, brownish swelling was seen back of the iris on the temporal side. Tension normal. The eye was enucleated and no tumor was found in the orbit, but an aneurism of the ophthalmic artery. There was no tumor in the eyeball, but miscroscopically, a cystic condition of the pars ciliaris retinæ. The tumor seen clinically was probably a large cyst, which ruptured on opening the eyeball.

Phenacetin. This agent is an analgesic derivative of phenol occurring in white scales or crystals, very soluble in water. It is rarely used locally in ocular affections, but is occasionally prescribed in 5-20 gr. doses in iritis and other painful diseases of the eye.

Phenakistoscope. An instrument for producing a representation of objects in motion by superposing images upon the retina of the eye in quick succession.

Phenazone. See **Antipyrin,** p. 521, Vol. I of this *Encyclopedia.*

Phengophobia. Photophobia. A fear of light.

Phenic acid. See **Phenol.**

Phenic alcohol. See **Phenol.**

Phenol. Carbolic acid. Phenyl hydrate. Phenic acid. Phenylic acid. Phenic alcohol. Benzophenol. A coal-tar distillate—hydroxybenzene—contains about 96 per cent. of pure phenol. The latter is a colorless, crystalline, acicular solid with a faint aromatic odor. It is very deliquescent and a small quantity of water transforms it into an oily liquid that reddens if the phenol contain the least impurity. When much diluted it has a sweetish and not unpleasant taste. It is readily soluble also in glycerine and olive oil. It is a powerful poison and forms salts or compounds with many bases. Some of these carbolates are employed in ocular therapeutics.

Carbolic acid is incompatible with camphor, lead acetate, menthol, resorcin, thymol, collodion and several other agents employed in ocular therapy.

This is one of the most effective germicides in the pharmacopeia but it has a very limited application to the eye proper owing to its extremely irritating properties. A 95 per cent. mixture with glycerine is a good cautery for non-serpiginous ulcers of the cornea. After staining (see **Fluoresceine**), irrigating and anesthetizing the globe the diseased area should be thoroughly probed with the point of a wooden tooth-pick soaked (not merely dipped) in the solution, excessive fluid being removed from the tooth-pick with blotting paper. This procedure may be repeated several times if necessary. Inasmuch as the phenol whitens the ulcer-area it is easy to regulate the application. Success depends upon using as little as possible of the cauterant and tattooing it well into the infected spot. There is little or no destruction of true corneal substance by the carbolic acid and, consequently, a minimum amount of scarring.

Although now rarely used as an eyewater or on dressings intended for the eye, it is employed for sterilizing instruments, sutures, etc., intended to be used in operative work. The Editor is in the habit of immersing cutting instruments for disinfection in 80 to 90 per cent. phenol in glycerine for 10 to 15 minutes in preference to boiling them. They are afterwards transferred to sterile water or alcohol which readily removes the phenol and keeps them free of dust and germs before and while they are in use.

Although irritating as a collyrium or anti-bacterial eye lotion it is sometimes prescribed in 1-1,000 to 200 watery solution.

In ulcers of the cornea and in infective conjunctivitis Perry Fulkerson uses the following collyrium, to be dropped into the eye every two or three hours: ℞ Acidi borici, gr. xxx; Cocain. muriatis, gr. x; Acid, carbolic., gr. viii; Aquæ dest. ad fl. ℥iv.

The irritating local character of carbolic acid is often seen. For

example, Exner (*Woch. f. Ther. u. Hyg. des Auges,* March 20, 1913) reports a case of gangrene of the lids and loss of an eye following the application of a carbolic acid lotion for hordeolum.

Phenol iodide. See **Paraiodophenol.**

Phenol, Iodized. IODIZED CARBOLIC ACID. SOLUTION OF IODINE IN GLYCERINE-CARBOLIC ACID. This is one of the preparations of the *Natl. Form.* which directs that it be made from iodine 20 parts, phenol 60 parts and glycerine 20 parts. Applied pure to corneal ulcers it is one of the most effective cauterants and germicides we possess. It is believed to be in that respect even better than pure tincture of iodine or pure phenol used alone. Of course, it is to be carefully rubbed into the stained, cleansed and cocainized cornea by means of a pointed tooth-pick or wooden match, soaked in the fluid. See, also, **Paraiodophenol.**

Phenomenon means generally any fact of observation, and, philosophically, any fact, appearance, or occurrence manifest to perception or consciousness; that which is apprehended by the mind, whether by consciousness or through the senses, in contrast with or in opposition to that which really exists, or to things in themselves. (*Standard Encyclopedia.*)

Phenomenon, Aubert's. An optic illusion, in which when the head is turned towards one side a vertical line appears to incline towards the other side.

Phenomenon, Becker's. Pulsation of the retinal arteries in exophthalmic goitre. See **Exophthalmic goitre.**

Phenomenon, Bell's. An outward and upward rolling of the eyeball on the attempt to close the eye: it occurs on the affected side in peripheral facial (Bell's) paralysis.

In addition to the description of this sign on page 928, Vol. II of this *Encyclopedia,* Kraupa (*Ophthalmic Year-Book,* p. 291, 1913) reports a case which he makes the occasion for a discussion of Bell's phenomenon, the physiologic upward outward movement of the eyeball during closure of the lids in a state of muscular relaxation. Kraupa's case was not one of facial paralysis, but of lagophthalmus due to a defect of the outer end of the upper lid, secondary to orbital caries in a tuberculous child. The other side was normal. Gentle closure of the lids was accompanied by outward rotation of both eyes, the cornea of the affected left side being covered to within 2 mm. by elevation of the lower lid. In forced closure of the lids both eyeballs at first made a slight excursion outward, then suddenly turned down beneath the lower lids. In sleep also the eyes were turned constantly downward. A successful plastic operation on the lid, after removal of an orbital

exostosis, resulted in restoration of the normal Bell's phenomenon, closure of the lids being invariably accompanied by turning of the eyes upward and outward. As regards the general subject of the relation of Bell's phenomenon to facial palsy, Kraupa concludes that if the sign is absent, the localization of a paralytic lesion is to be regarded as supranuclear.

Phenomenon, Galassi's pupillary. Same as *Westphal-Piltz phenomenon.*

Phenomenon, Jaw-winking. Raising of the upper eyelid when the jaw is pressed downward, and slight ptosis when the mouth is closed. See p. 6713, Vol. IX of this *Encyclopedia.*

Phenomenon, Orbicularis. Same as *Westphal-Piltz phenomenon.*

Phenomenon, Paradoxical pupil. Same as *Westphal-Piltz phenomenon.*

Phenomenon, Purkinje's. Fields of equal brightness but different color become unequally bright if the intensity of the illumination is decreased.

Phenomenon, Westphal-Piltz. Contraction of the pupil, followed by dilatation, after vigorous closing of the lids; caused by tension of the orbicularis muscle.

Phenosalyl. A powerful antiseptic mixture made by heating together 9 parts of carbolic acid, 1 part of salicylic acid and 0.10 parts of menthol. It is recommended as a collyrium in 0.20 to 0.40 per cent. watery solution, especially for various forms of conjunctivitis.

Phenyl hydrate. See **Phenol.**

Phenylic acid. See **Phenol.**

Phenylis salicylas, U. S. See **Salol.**

Phenyl salicylate. See **Salol.**

Phenylurethane. See **Euphorin,** p. 4550, Vol. VI of this *Encyclopedia.*

Philalethis collyrium. An old collyrium containing myrrh, opium, washed lead, Samian earth, gum tragacanth, stibium coctum, starch, washed animal charcoal, washed ceruse, and rain-water.

Phineus. A blind soothsayer of Greco-Roman mythology, son of Agenor, and King of Salmydessus in Thrace. He was twice married. His second wife, Idaea, falsely accused his two sons by his former marriage, Polydectus and Polydorus (or Oarthus and Crambis, as the names are sometimes given) of having attempted to seduce her. Thereupon Phineus put out their eyes. As a punishment, the gods blinded the father, and also set the Harpies on him. These always either devoured his food or defiled it, or carried it off. When the Argonauts came to Thrace, Phineus gave them excellent directions in regard to their further course, and, in return for the favor, the sons of Boreas,

Zetes and Calaïs, delivered him from the torturing Harpies.—(T. H. S.)

Phlebectasies. Dilation of a vein. A hemangioma.

Phlebitis. Inflammation of a vein.

Phlebolith. See **Eyelids, Phlebolith of the,** p. 5020, Vol. VII of this *Encyclopedia.*

Phlebosclerosis. Hardening of a vein, especially of its intima.

Phlebotomy. Venesection. General blood-letting. In the revulsion of feeling and the reversal of public and professional opinion this method of lessening blood-pressure, removing the volume of toxic blood, reducing abnormal temperature and of relieving the pain and congestion of inflamed tissues has almost been forgotten. There is still a place, however, for this remedy, especially in cases of acute iritis, acute inflammatory glaucoma, scleritis, threatened panophthalmitis occurring in robust, full-blooded individuals that were benefited by "letting blood" in the good, old way. Webster Fox has voiced this sentiment quite recently and the ophthalmologist would do well to bear it in mind.

From four to ten ounces of blood may be drawn from the upper arm and the venesection may be repeated if necessary.

It has been said that the American is not a fit subject for phlebotomy, and it is quite true that the systemic and local effects of this form of depletion may usually be reached by purgation, counter-irritants and such local lymphagogues as dionin, but there still remains a class of plethoric individuals in whom acute outbursts of inflammatory eye disease urgently call for more potent remedies.

Excepting in cases of extreme anemia, hemophilia, senile cachexia, Kyrieleis recommends venesection in relapsing ocular hemorrhages, and if not successful, as a last refuge, ligature of the common carotid. However, he believes venesection has advantages over ligature: under aseptic precautions it is a perfectly harmless procedure and it may be repeated without damage as often as required.

Phlegmon. Inflammation of the connective tissue of an organ leading to ulceration or abscess. See, for example, **Eyelids, Abscess of the,** p. 4988, Vol. VII of this *Encyclopedia;* also **Orbit, Abscess of the.**

Phlogogenous. Productive of or exciting inflammation.

Phloroglucin method. See p. 6905, Vol. IX of this *Encyclopedia.*

Phlyctena pallida. A term applied by Hirschberg to vernal conjunctivitis. See p. 3170, Vol. V of this *Encyclopedia.*

Phlyctenophthalmia. Ophthalmia with the formation of vesicles.

Phlyctenula pallida. A synonym of vernal conjunctivitis. See p. 3170, Vol. V of this *Encyclopedia.*

Phlyctenular conjunctivitis. Phlyctenules of the conjunctiva. See

Conjunctivitis, Phlyctenular, p. 3131, Vol. V of this *Encyclopedia*. See, also, under **Phlyctenular ophthalmia.**

Phlyctenular keratitis. See p. 6798, Vol. IX and p. 3433, Vol. V of this *Encyclopedia;* as well as under **Phlyctenular ophthalmia.**

Phlyctenular ophthalmia. That phlyctenules may at the same time develop in the cornea, conjunctiva and sclera is well known, and that the lesion in either situation is probably an expression of the same pathologic entity is generally believed. Hence the expression "phlyctenular disease" or "phlyctenular ophthalmia" furnishes a common ground on which to discuss the whole subject.

Consequently, in addition to what is given under the captions **Phlyctenular conjunctivitis** and **Phlyctenular keratitis** it may be said here that Hayashi (*Klin. Monatsbl. für Augenh.*, Nov., 1909), comments on the lack of harmony displayed by authors who discuss the pathology of the disease. He gives the results of his own researches in five cases of keratitis, and six cases of conjunctivitis, all of a phlyctenular character. In each instance the material for examination had been obtained by excision during life.

He submits the following points with regard to corneal phlyctens. The first changes are found in the parenchyma of the cornea, under Bowman's membrane and the epithelium, both of which, however, sooner or later undergo a process of necrosis; he contradicts absolutely von Michel's view of vesicle formation, and he is unable to find in fresh foci any new-formed vessels. One case, that of an obstinately recurring keratitis in a patient aged thirty-two, showed a caseating nodule under Bowman's membrane surrounded by granulation tissue, but it was impossible to demonstrate any micro-organisms in it, and inoculation experiments gave negative results.

In another case, that of a girl of sixteen years of age, obviously, according to his account, riddled with tubercle, he found several isolated phlyctens, one of which he excised; glands in the neck excised subsequently showed typical tuberculous changes, and the histological appearances in the excised phlycten were similar to those in his former case; one other case in a twelve year old girl showed similar results.

Hayashi discusses the possibility of ectogenous and endogenous infection, and apparently is of the opinion that phlyctenulæ in general result from an infection with the toxines of tubercle bacilli, a view which seems reasonable enough when applied to some cases in his own series, but which can hardly be said to apply to all cases of phlyctenular ophthalmia.

Attention to the fact that the tuberculous or para-tuberculous origin of phlyctenular affections is now pretty well established, is once more

emphasized by Sydney Stephenson and J. A. Jamieson. This opinion is founded upon, (1) the frequency with which a family history of tubercle can be obtained from the subjects of phlyctenular disease; (2) the frequent co-existence, along with phlyctenular disease, of other manifestations of tuberculosis; (3) the fact, as shown by the experimental work of Nias and Leslie Paton, that the blood of patients suffering from phlyctenular disease behaves in a manner typical of a definite tuberculous infection; (4) the positive result obtained in phlyctenular cases by employing a specific test for tubercle.

The writers recently employed von Pirquet's test in 20 cases of phlyctenular affections in children, and a positive result was obtained in every instance; 50 per cent. of these patients presented more or less obvious signs of tubercle, medical or surgical, while 75 per cent. gave a family history of tubercle.

Rubert's (*Wien. Med. Woch.*, Feb. 1, 1913) experiments on animals show that phlyctenular affections in the eye can be produced only in tuberculous animals or in healthy animals which had previously been treated with tuberculin. Phlyctenular nodules are not produced by the local action of the microbes, but by the products of metabolism of these microörganisms. Tuberculous infection of the system must precede the formation of the phlyctenules. An exudative diathesis or an intestinal autointoxication, without the presence of tuberculosis, can never be considered an etiological factor in this disease. An external irritant is also a *sine quâ non* in the production of phlyctenular inflammation. In old people, a phlyctenular nodule may make its appearance at the limbus; such phlyctenule may have been produced by the Koch-Weeks bacillus, but in the well-known form of kerato-conjunctivitis recurrens in young individuals phlyctenule is always superimposed on scrofula. Pannus, in cases of trachoma, also manifests itself in scrofulous individuals.

Belelousky-Raskin (*Zeitschr. f. Augenheilk.*, June, 1913; review in *Ophthalmic Review*, p. 383, Dec., 1913) examined the tuberculin reaction in 100 consecutive cases of phlyctenular ophthalmia, both by von Pirquet and Moro's methods.

The von Pirquet's reaction was tested in the way recommended by Sähli. In this modification six inoculations are made in the upper arm. Into one of these old tuberculin was inserted and into the others diluted tuberculin in the strength of 1 : 10, 1 : 100, 1 : 1,000, 1 : 10,000, while the last one was kept as a control.

The results were as follows:—v. Pirquet was positive in 92 per cent. of the cases and negative in 8 per cent., while Moro was positive in 85 per cent. and negative in 15 per cent. All the cases that were positive

with Moro were also positive with v. Pirquet, whereas of the 15 Moro-negative cases seven were positive with v. Pirquet. From this fact the author deduces the belief that v. Pirquet is more reliable than Moro, though an unkindly critic might be justified in taking an opposite view. All the positive v. Pirquet results reacted with both the old tuberculin and the 1 : 10 dilution. Fifty-one cases reacted with the 1 : 100, and 15 with the 1 : 1,000. The nature of the reaction was not different in the corneal and conjunctival forms of the affection. Tables show that the number of positive reactions increase with the age of the patients. Of the eight patients in whom the reaction was negative, in three, father, mother and sister respectively, all suffered from tuberculosis, and the others had neck glands or some other possibly tuberculous affection. The author, therefore, concludes that in all the cases tuberculosis was an etiological factor in the disease.

As it has recently been suggested that auto-intoxication from the bowel is of importance in this connection, the author investigated the urine by Jaffe's indican reaction in 30 typical cases, and failed to obtain a single positive result.

The author concludes a summary by suggesting that in treatment we should take into account the tuberculous condition, and not be content with dealing only with the local affection.

Allan (*Pediatrics*, April, 1913) holds that while there may be many contributing causes, there can be but little doubt but that in the majority of cases tuberculosis is the important etiological factor. Attention to the general health, to errors of refraction, to the naso-pharynx, and the instillation of adrenalin 1 : 6,000 gives excellent results in cases with severe blepharospasm. Knorr comes to the same conclusion as to the etiology of phlyctenular disease. From his studies of the urine of normal individuals and also of patients suffering from trachoma and phlyctenular kerato-conjunctivitis respectively, Signorino (*Ophthalmic Year-Book*, p. 116, 1913) states the following conclusions: Indicanuria, when inconstant in occurrence and unaccompanied by other disturbances, is not to be regarded as a certain sign of auto-intoxication. It may occur in perfectly healthy individuals. The constant finding of indicanuria, while it does justify a suspicion of augmented intestinal decomposition, does not of itself establish a diagnosis of enterogenous auto-intoxication. Indicanuria is quite inconstant in phlyctenular kerato-conjunctivitis, and in the rare cases in which it can be demonstrated it has no pathologic value in this disease and is merely to be regarded as an accidental finding. Enterogenous auto-intoxication is not to be regarded of much importance in the etiology of phlyctenular disturbances, although it may act as a coadjuvant and

predisposant, just as may any other cause which diminishes the resistance of the organism. Colombo lays great weight on indicanuria as an evidence of intestinal intoxication in patients suffering from eczematous kerato-conjunctivitis, and is inclined to think that such intoxication is the cause. Indicanuria was present in 82.6 per cent. of the cases examined.

Burns (*Ophthalmic Record,* August, 1912) has also presented an important contribution to the etiology of phlyctenular ophthalmia. He believes that the ocular and cutaneous tests, especially the very delicate skin test, have shown that many patients with phlyctenules are tuberculous. Even the cutaneous test forces us to admit that from 25 to 10 per cent. are not. The writer's tables show that 36.2 per cent. of his phlyctenular children were not tuberculous. Hamman and Wollman, after 1,500 experiences, regard a negative skin reaction as very strong evidence that the child is not tuberculous. The writer does not believe, therefore, that the results of the cutaneous and ocular tests prove that phlyctenular disease is due to the action of a tuberculous toxin, but only that tuberculosis prevails among the children seen in our clinics to a much greater extent than was formerly realized. As tuberculosis has been estimated by means of the skin test to be present in from 71 to 94 per cent., it would be astonishing if we did not find it prevalent among those with phlyctenular disease.

In discussing this paper R. J. Tivnen said that his experience was not in consonance with that of Bruns; that it is rare to have opacities following phlyctenular trouble seriously interfere with sight. His experience was that they are neither infrequent nor rare. After a study of 50 cases of phlyctenular disease as to its etiology, he was not quite in agreement with Bruns as to the negative rôle of tuberculosis. The average age of these patients was found to be 12¼ years. Lymphoid complications occurred in 64 per cent.; 20 per cent. had a tuberculous family history, and 12 per cent. a personal tuberculous history, active or latent. The von Pirquet reaction was positive in 92 per cent. An ocular reaction accompanying the von Pirquet test occurred in 8 per cent. Rise in temperature occurred in 88 per cent. following the first injection. The clinical course, chronicity, tendency to recurrences, predilection for the poorly-nourished, glandular complications and response to tuberculin point to a tuberculous etiology. The failure of a certain percentage of cases to react is not greater than that associated with almost any other of our diagnostic methods, and, in addition, we may not be able to interpret correctly our tests. As explained by Derby, phlyctenules may be an atypical form of tuberculosis and free from bacilli. Tuberculous victims are particularly favor-

able subjects for the development of ocular infections. The objection that phlyctenular disease occurs in the non-tuberculous and not in many tuberculous subjects may be answered by saying that it is not always possible to determine tuberculosis. While the tuberculosis theory is not absolutely established, sufficient data have been accumulated to warrant further thoughtful consideration.

Arthur G. Bennett, of Buffalo, agrees largely with the opinion of Bruns. In the children's hospital he always has a von Pirquet reaction taken and the urine examined. In every case the urinary examination shows a marked excess of indican, and his experience has been that most cases of phlyctenulosis are due to intestinal toxemia. He regards the tuberculous reaction more as a coincidence than an actual etiologic factor. In Buffalo there are 90,000 Poles, and their children are kept under the most deplorable hygienic surroundings. It is these children who break out with phlyctenulosis. A noteworthy clinical observation is the vile odor of the urine. To counteract it, the therapeutic measure outside of proper feeding found to be of greatest value is the administration of small doses of sodium salicylate, 1 or 2 gr., three times a day.

Samuel Theobald is quoted as saying that Fuchs and other German authorities call phlyctenular conjunctivitis or keratitis, as the case may be, eczema of the cornea. That in his judgment is the true nature of the affection, and he is thoroughly convinced that phlyctenular trouble is due to the same cause. He had long taught that phlyctenulosis was due to infection from the alimentary canal, and while such a condition is more likely to occur in a tuberculous or scrofulous subject, it occurs over and over again in children who show not the slightest sign of a tuberculous condition, but cases occur under bad hygienic surroundings. He agrees with Bruns that only in rare instances is it tuberculous. One of the most valuable remedies is a good, energetic calomel purge. It should be given at once at the beginning of the treatment, and it at once brings about a change for the better.

Hiram Woods, of Baltimore, thinks that without scientific tests a little improvement in hygiene will help these children to resist the constantly recurring infection from the nose or from the outside. Clinicians are making a careful distinction in children between a tuberculin skin reaction and clinical tuberculosis. Probably 75 per cent. of all children, irrespective of all symptoms, will give a positive von Pirquet reaction. What are we to infer from that? Von Pirquet told him that he thought two negative results in children were positive proof of the absence of tuberculosis, but he himself did not attach an enormous importance to the positive result of the reaction as regards clinical

tuberculosis. If, on the other hand, tuberculin cures the disease, then we have got some positive proof.

Indican undoubtedly represents the absorption of indol, and indol is one of the conjugate sulphates resulting from intestinal putrefaction. Many internists say it is positive proof of intestinal intoxication. Many others dispute this assertion. In a recent communication de Schweinitz said he was surprised that the profession had not gotten rid of the fetish of indican. The argument against indican is that patients have these troubles without it; that they must have these troubles from some other cause and get well in spite of the presence of indican.

James W. Barrett, of Melbourne, Australia, mentions that his experience has been that of Bruns and Woods. It is a disease found frequently in Melbourne, but almost never in private practice. It is almost invariably found in hospital practice. The Australian population has curious dietetic habits. The diet of children is almost entirely of carbohydrates. They have bread and butter and jam and tea for breakfast, bread and butter at eleven o'clock, a fair meal of meat and pudding at one o'clock, another piece during the afternoon, and end with tea and bread and butter in the evening. The result is that the intestine must be loaded with cellulose, just as among the Egyptians. He did not know the habits of the people Bruns deals with, but the reference to intestinal toxemia interested him very much, knowing what he does of what happens in Australia. Syphilis has no relation to phlyctenules, and he believes that the von Pirquet phlyctenule is not necessarily associated with tuberculosis.

Samuel Theobald (*Jour. Am. Med. Assocn.*, p. 566, 1914) maintains that the evidence adduced in support of the doctrine that phlyctenular ophthalmia is a tuberculous or pseudotuberculous lesion is far from convincing.

The frequency with which the subjects of phlyctenulosis give a positive reaction to diagnostic tuberculin tests is of little significance in view of the fact that the same tests show a scarcely smaller percentage of positive reactions in healthy persons.

There is excellent authority for the contention that "until some responsible observer has demonstrated the presence of the tubercle bacillus in an extended series of phlyctenules," or, at least, until it has been shown to be sometimes present, the assertion that the affection is, in any sense, tuberculous is without warrant.

In the present state of our knowledge of the etiology of phlyctenulosis, the employment of tuberculin as a therapeutic agent in this affection is unjustifiable, not only because the ill-considered use of tuberculin is capable of doing much harm, but also because the clinical

evidence shows pretty clearly that, if it is not actually harmful, it surely is not helpful. Definite clinical signs of the existence of tuberculosis, apart from the ocular inflammation, may justify the administration of tuberculin, but even in such circumstances the effect on the eye could be only indirect.

The writer further says that as phlyctenulosis is essentially a disease of childhood, and the typical cases occur not in adult life, but in children, it is from the study of these cases that trustworthy conclusions as to the etiology of the affection are to be drawn. The study of these childhood cases shows, from the almost constant association of facial eczema with the ocular inflammation, that phlyctenular ophthalmia, as was formerly very generally held, is an ocular eczema, due, for the most part, like the facial eczema, to intestinal intoxication, and that tuberculosis is seldom, if ever, an etiologic factor.

Finally, Will Walter (*Jour. Am. Med. Assocn.*, p. 1144, 1913), in an exhaustive study of the subject, thinks that in the determination of the probable fundamental factor in a given case we have first to consider, because of its universal prevalence, the probability of an underlying tuberculosis. It is the great possibility of variation, not only in the attenuation of the infector but in the variability of the antibacterial immunity present, which makes the problem so complex. Studies of the opsonic index have been made and negative phases to tuberculosis have been found to precede the evolution of a phlycten. This may be accounted for by auto-inoculation from a reactivated focus. The appearance of the phlycten thus might properly be termed an "auto-Calmette." An opsonic observation of many cases, however, has convinced him that this negative phase is not present in the majority of cases and obviously would only occur in cases in which the auto-inoculation was considerable. "In the determination of the presence or absence of scrofulosis it would seem, as I have pointed out before—the result of frequent observation—that a variable opsonic index, not as to whether it is low, but whether it is greatly variable, points to the occasional auto-inoculation and the presence of an active focus somewhere in the body. I take this to be a better barometer than a continuously low index."

The writer adds that it must be apparent to an unbiased observer that no advantages accrue from a large diagnostic dose over a minute dose therapeutically administered but giving a diagnostic reaction; for a therapeutic administration of tuberculin which has produced a reaction has established a diagnosis of sensitiveness, and that is the aim of the test. Such a diagnostic measure may indeed serve both for diagnosis and for control of therapy, a guide to subsequent administra-

tion. The second test of reaction, and one which Sahli recommends, is the examination of the leukocyte count for an increase. The leukocyte reaction is thought to offer the mildest reaction possible and is the one which he employs for therapeutic guidance.

He accepts the Wolff-Eisner theory of lysin formation as the cause of the tuberculin reaction, and the fact that an autogenic immunity is adequate to preserve life in 85 per cent. or more cases shows at least that a sustained resistance is established, a condition Walter proposes to call "defensive equilibrium." Wolff-Eisner assumes the existence in the tuberculous infected macro-organism of amboceptors or lytic bodies, and bases his theory on the well-known allergic reactions which follow the injection of albuminous substances, parentally, namely, the formation of albumin-dissolving substances, albuminolysins. After the first injection they are present in the circulation and the macro-organism is sensitized to subsequent injections. These lysins are formed in excess of the requirement of the first injection.

When tuberculin is inoculated in a case in which there has been a preinfection with tuberculosis, there is a speedy cleavage due to the presence of the lysin, the formation of tuberculinolysin, which itself forms, first, primary lytic antibodies, leading to attenuation and destruction of bacilli acting directly (bacteriolysins), then secondary antitoxic antibodies which neutralize the toxicity of the lysinized tuberculin, as well as the lysinized tubercle bacilli themselves.

Tuberculin (injected) + lysin (already in body) = first, the formation of tuberculinolysin, increased toxicity, leading secondarily and later to the formation of antibodies antitoxic thereto.

If body-made bacterial protein produces such manifestations as phlyctenas and episcleritis, why does not ectogenic tuberculin produce the same manifestations? The answer contains both the proof of the Wolff-Eisner theory and the strongest possible argument for small dosage. An irritation shown in the foci or in the production of a phlyctena not only furnishes the proof of the Wolff-Eisner theory but shows that the dosage has been too large, has been greater than the serum content of antibodies can control, has done temporary harm.

Hence, argues Walter, since the toxin formed by the tuberculinolysin is the cause of the reaction, any excess of tuberculin would produce a reaction and that reaction would evidence lack of antitoxic antibodies in the serum. For that reason, as will be stated in connection with the therapy, only reactionless therapy may safely be employed.

The writer says, speaking of *general therapy in this disease*, that William F. Norris inherited from Von Graefe the treatment of phlyctenular ophthalmia which was employed in his service at Wills Eye

Hospital in the early days of American ophthalmology. This treatment is still in vogue in the clinic of his successor and is a beneficent example of empiricism in the specialty. It was based on careful observation of therapeutic effects.

This *treatment* consisted in the withdrawal of all cane-sugar combinations, all acids, tea and coffee, and the sterilization of the intestinal tract by absorbing doses of calomel continued over many days; they substituted fresh air, nourishing, bland diet—a good basis for the natural immunizing treatment of to-day.

Phlyctenule. A minute vesicle, pimple or nodule, generally seen after ulceration has set in, of the conjunctiva or cornea. See p. 3434, Vol. V of this *Encyclopedia.*

Phonopsia. The realization of colors by the hearing of certain sounds.

Phonopticon, Crystal. An instrument that suggests d'Albe's optophone. It was devised by F. C. Brown (*Outlook for the Blind,* 1915) of the State University of Iowa. This "mechanical eye," intended to stimulate the remaining functionating fibres of the optic nerve so that the "blind may see" and especially read, is figured in the illustrations, which show schematically the working of the instrument. The page, bearing the letter *A*, for example, lies before a lens. The page remains stationary while the lens (5) and the selenium crystals (1) are moved together over the line of letters. A bright band of illumination (6b), whose source is not shown in the diagram, moves with the lens and illuminates strongly each letter in succession. Let the band of illumination be in the position indicated, and approaching the letter *A*. As the successive parts of the letter come into the light their images are thrown by the lens on the corresponding crystals; the upper crystal will receive the successive images of the lower parts of the letter, the lower crystal those of the upper parts of the letter, and the central crystal the images of the central parts. The lower left part of the *A* enters the illuminated region first, and the upper crystal will be the first to respond. Next, the central crystal will respond, and by the time the lower crystal is reached, the upper one will have ceased to respond, as the lower left part of the letter has passed out of the region of illumination. The central crystal will continue to act, due to the continuance in the band of the horizontal line of the *A*. As the letter passes on, the lower crystal will cease to respond, because the apex of the *A* has passed out of the band. Next, the central crystal will cease to act soon after the upper crystal responds to the entrance into the band of the lower right part of the letter. Likewise the upper crystal will be the last to cease action. It is thus seen that every letter of the alphabet, and in general any character whatsoever, will have its characteristic sound.

In the same figure the diagram of electrical connections shows how the responses of the crystals are made evident in telephone receivers. Each crystal forms an arm of a Wheatstone bridge. The telephone receiver for that crystal replaces the galvanometer of the Wheatstone bridge as ordinarily used. Three telephone receivers are drawn in the diagram, but if three or even more crystals need to be used, the solu-

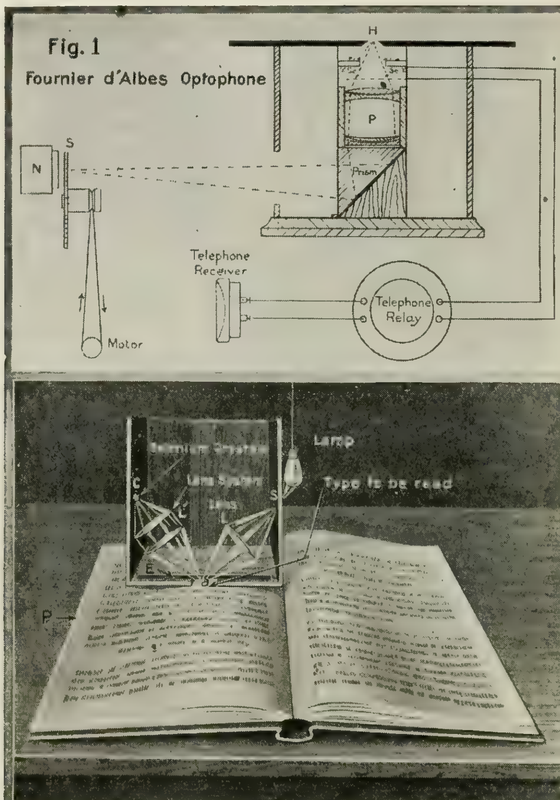


Fig. 4 How the Mechanical Eye is used

tion in behalf of only two ears is seen from Fig 2 of this diagram. According to this figure, with two telephone receivers four crystals are readily accommodated. However, the instrument appears to give very good results with only two crystals, one for the upper, the other for the lower part of the letter.

In series with each telephone receiver there is an interrupting device giving a definite frequency to the current, and a resonating arrangement in the receiver changes this frequency to one of definite musical

pitch, a different pitch for each crystal. It is a change in the intensity of one of these pitches that marks the entrance into the band of illumination of a region of darkness, such as a portion of some letter.

The photograph shows the whole apparatus in its present stage of development. The total weight is only 35 pounds, while the mechanical eye, which is the upright closed box, shown in position for reading

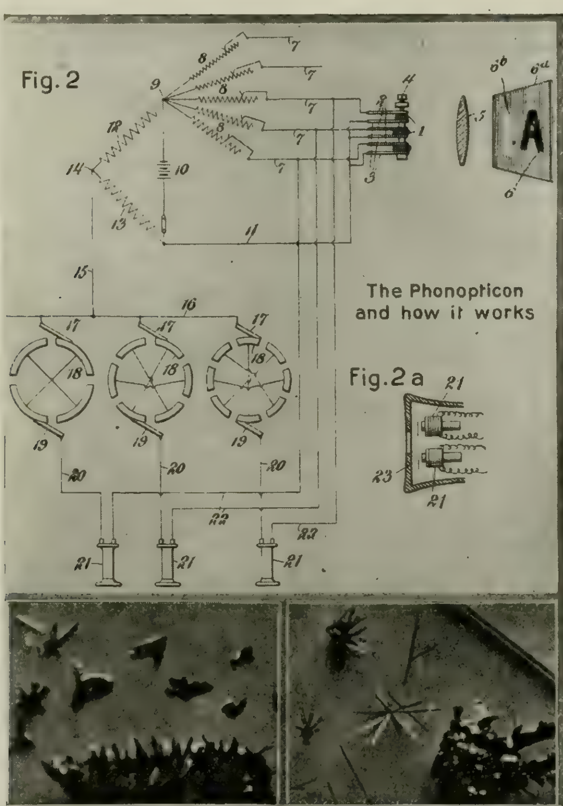


Fig. 6 Selenium Crystals used to make the Mechanical Eye

from a book, weighs but two pounds, and its weight can probably be reduced to a fraction of a pound.

This box contains the crystals (which respond to the light in a manner similar to the action of the rods and cones of the human eye), the source of illumination producing the band of light on the page, and the necessary lenses, together with some minor parts. The lens and crystals as shown in Fig. 2 are mounted in the box, so that with the page lying upon a table the line joining them makes a certain angle

with the vertical, as in Fig. 4. In this last figure S is a source of light, such as the filament of a Nernst glower or of a special incandescent lamp, L, the lens to focus the light on the letter at a on the page P, through an aperture in the bottom of the box E, L, the lens system to receive the reflected, or diffused, light and focus it, in the form of an image of the illuminated part of the page, upon the crystals at C. The mechanical eye is seen with the cover removed in the large photograph, Fig. 5.

Compared with the optophone of d'Albe the phonopticon is a decided advance. By the use of isolated crystals rather than masses of selenium of minute crystalline form, in selenium "cells," a sensitiveness a hundred times greater has been obtained. Because of this increased sensitiveness due to the crystals, the practicability of the instrument does not depend so much upon highly sensitive conditions in the telephone receivers. It is almost astounding that Brown used but two crystals at a recent exhibition, one for the upper, the other for the lower part of the letter, as compared with d'Albe's eight holes and as many musical frequencies. Two, or even four, musical frequencies are more easily attended to by the operator than eight. In d'Albe's device letters are to be distinguished by the omission of certain tones, while the phonopticon of Brown responds positively according to what is in the field; in other words, the entrance of a letter causes the tones to sound. Also, the audible tones of the phonopticon are very distinct, which are not true of the earlier instrument; and they can be made as loud as would be desirable. The phonopticon, furthermore, does not require a relay for the purpose of intensifying the sound as does the optophone. In the d'Albe instrument the book or newspaper is inverted over the apparatus, and must itself be moved past the aperture. The disadvantage of this with large and heavy books is apparent. No matter how heavy the book the mechanical eye of the phonopticon is moved with equal ease over the page. By means of a simple adjustment of the "eye" the phonopticon can be adapted to varying sizes of type, corresponding to a similar adjustment in the d'Albe instrument. The great difference between the phonopticon and its predecessor lies, of course, in the use of selenium crystals rather than cells.

It is not every piece of work of purely scientific character that proves to have an immediate and direct practical application. The case of the new selenium crystals first produced by Dr. Brown, however, is one of the notable exceptions. Pure science is his field and he has stepped aside temporarily only that the clearly seen possible benefit of the new crystals to the blind should be realized. The historic scientific background explaining the final production of the crystals is as follows:

To the research worker in physics the problem of the conduction of electricity through metals has been one of the most fascinating and baffling with which he has had to deal. The metal selenium has been one of the most promising for research along this line because of the property already mentioned of changing its electrical resistance in passing from one intensity of light to another. Work with selenium

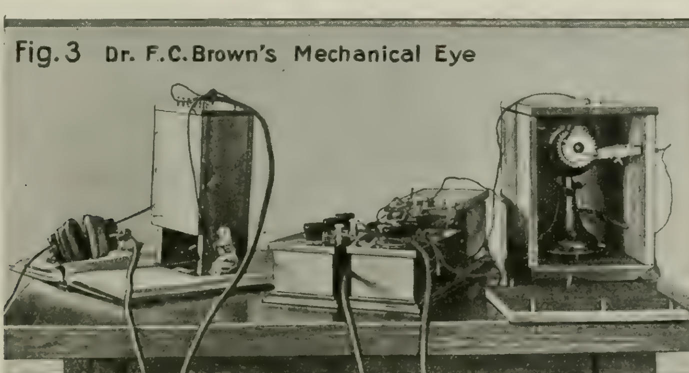


Fig. 3 Dr. F.C. Brown's Mechanical Eye


Fig. 5 A Telephone for the Eye

is doubly important for the possible information it may give concerning the known intimate relation between electricity and light. Scientific workers on selenium have hitherto been restricted to experimentation with selenium "cells"—at least these cells have offered the most fruitful field. The cells, as was stated, are composed of a mass of selenium of minute crystalline grain, crystallized in situ from an amorphous form, over a wire wound spirally about a small slab of soap-

stone or similar material. The electric current used for the study of the cell passes partly by way of the wire and partly through the selenium mass bridging over the spaces between successive turns of the wire. As the selenium bridges change their resistance with varying intensity of the incident light, the total current passing through the cell, of course, changes also. Now there have been several facts of uncertain interpretation regarding selenium, uncertain because of the necessarily complex conditions inherent in a selenium cell. It was apparent to Brown and his associates at Iowa University that if they could isolate crystals of metallic selenium of sufficient size to be worked with individually, a number of these disputed points might more easily be settled. Turning their attention to the production of selenium crystals, they were finally rewarded with crystals of the desirable size. Altogether about four years' labor have been necessary to produce desirable results. The method of crystal production is to inclose the uncrystallized selenium in a glass tube, raise the tube to a high vacuum, sealing it shut while in this condition, and then to place the tube with its contents in an electric oven, where it is kept at constant temperature for weeks and even months before the selenium crystals have grown to the desired size. Some of them required three months in the electric oven at a constant high temperature. The slow process of crystallization proceeds by the distillation of the amorphous selenium, and the crystals are found clinging to the upper walls of the tube. Photographs of the crystals, reproduced from the *Physical Review* and the *Philosophical Magazine,* are shown in Fig. 6.

With these large crystals there have already been settled several of the uncertain points regarding the action of light on selenium, while numerous questions that the crystals and not the cells can satisfactorily answer await further investigation. The progress of this scientific work is recorded in articles that have appeared recently, chiefly in the *Philosophical Magazine* and the *Physical Review.* Some of the more interesting facts dawn from a study of the crystals are: that the seat of light action in selenium is in the mass of the selenium itself and not at its contacts with the electric circuit; that the crystals all show change in electrical resistance with exposure to light; that the resistance depends on the mechanical pressure to which the crystal is subjected, as well as on the light intensity; and, perhaps most remarkable of all, that the crystals possess a new property, hitherto unobserved in matter, and that is their power of transmitting the light action along their whole length apparently through some sympathetic response that takes place in the mechanism of the crystal structure. These are facts pri-

marily of scientific interest. The practical application of the crystals in the phonopticon is only incidental, although most important from an altruistic viewpoint.

Further work with the crystals promises even greater size and sensitiveness. With the phonopticon at its highest perfection the blind will not only be reading books and magazines accessible to anyone else, but will probably also be appreciating photographs and paintings, and possibly even viewing the landscape. See, also, **Optophone.**